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SEA LAMPREY SPAWNING: MICHIGAN STREAMS OF LAKE SUPERIOR

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Explanatory Note

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United States Department of the Interior, Oscar L. Chapman, Secretary
Fish and Wildlife Service, Albert M. Day, Director

SEA LAMPREY SPAWNING: MICHIGAN STREAMS OF LAKE SUPERIOR

by

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Special Scientific Report: Fisheries No. 70

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Introduction

During the three decades since the capture of the first specimen in Lake Erie in 1921, the sea lamprey (Petromyzon marinus) has established itself in great numbers in the upper Great Lakes. Partial destruction of the commercial and sport fisheries of Lakes Huron and Michigan has resulted. Details of the problem in those lakes have been presented in recent papers (Applegate 1950; Hile 1949; Hile et al. 1951).

The present situation in Lake Superior differs from that in Lakes Huron and Michigan in that the sea lamprey is still in its initial states of dispersal and establishment (first specimen taken at Isle Royale, 1946). The lamprey appears already to have caused some damage to the fish populations (especially lake trout) in the Superior basin. Commercial catches have declined (owing partially, perhaps, to increased fishing pressure) throughout the lake, but the greatest decrease has taken place in the eastern areas. If the relation between the fish populations and the sea lamprey follows the pattern established in Lakes Huron and Michigan, commercial fishing for lake trout and certain other species of present importance in Lake Superior will be unprofitable within three or four years.

Control of the sea lamprey in all of the lakes will probably be effected by attacking the parasite during one of the stream phases of its life cycle; for example, the upstream migrations of sexually mature individuals can be blocked by dams, mechanical weirs, and electrical barriers in streams suitable for spawning (Applegate and Smith 1951).

The relative importance of most of the watersheds of the Lake Huron and Lake Michigan basins as sea-lamprey spawning areas has been determined. Suitable spawning habitat is present in only a small percentage of streams in these basins. Unfortunately, those streams that do possess this facility have a tremendous potential for reproducing the species.

Before the stream surveys reported herein, little was known of the characteristics of the majority of the streams flowing into Lake Superior or of their relative importance as present or future producers of sea lampreys.

The surveys of Lake Superior streams were instituted to determine the following:

1. The extent of sea lamprey penetration westerly in Lake Superior, as judged by actual observations of lampreys, spawning activities, and nests in the tributary streams (sea lampreys are now distributed throughout the lake).

2. The location and extent of potential spawning and larval habitats in the streams of the basin. Criteria used to determine the relative suitability of streams were established by Applegate (1950) and other workers; specific water temperatures, velocities, and bottom types necessary for successful completion of the stream phases of the life cycle were determined.

3. The best sites for control structures in streams which are apparently suitable or are actually used by sea lampreys for spawning.

During the summer of 1950, all of the streams from the Tahquamenon River (Chippewa County, Mich.) west to the tip of the Keweenaw Peninsula were examined (figs. 1-17). The personnel included, in addition to authors, Clifford Brynildson, Daniel Garn, William Gaylord, Carl Jacoby, Alberton McLain, and Phillip Parker. The 1951 survey was conducted by Howard Loeb, William Gaylord, Carl Jacoby, and George Simmons; this party examined streams in the area between the tip of the Keweenaw Peninsula and the Michigan-Wisconsin border (figs. 1, 18-23).

Appreciation is extended to the Institute for Fisheries Research, Michigan Department of Conservation, for data on the Two Hearted River, and to Leo F. Erkkila of the Fish and Wildlife Service for data on utilization by the lamprey of several streams (table 23. Alan C. Bennett prepared the maps, and William Gaylord identified lamprey larvae.

Digest of principal findings

Results of the 1950 and 1951 stream surveys in the Lake Superior watershed are summarized as follows (figs. 2-17 and 18-23):

Number of streams and tributaries examined:

1950: 869 (Tahquamenon River west to the tip of Keweenaw Peninsula)

1951: 178 (tip of Keweenaw Peninsula west to Michigan-Wisconsin border)

Of the streams examined in 1950, detailed data were obtained for 330. (Tables 1-16 present information on the 112 streams which possessed some potential for reproducing the sea lamprey.) The remaining 539 streams which appear on large-scale maps of the area were found to fall in one of the following categories:

1. Nonexistent.

2. Considered from preliminary examination as not suitable for the reproduction of sea lampreys.

3. Tributaries not in need of examination because extensive potential spawning habitat had already been found in the watershed.

Detailed data were collected for all of the 178 streams examined in 1951 (tables 17-22). The 1951 survey was less extensive than that of 1950 in that most of the minor tributaries of each watershed were not examined.

However, all of the 315 watersheds flowing directly into Lake Superior from the Tahquamenon west of the Michigan-Wisconsin border (1950 and 1951 survey areas) have now been examined in sufficient detail for the purposes of this survey.

Streams with a large productive potential (Space for more than 75 nests): 53
Streams with a medium productive potential (Space for 6 to 75 nests): 117
Streams with a small productive potential (Space for 1 to 5 nests): 75

The standards on which the above groupings are based are, of course, arbitrary and are intended only to provide a convenient system of classification. Productive potential is defined as the capacity of a stream to produce sea lampreys, expressed as the number of nests which may be constructed on the spawning sites available when:

1. Certain less variable factors such as quality of gravel (Spawning material), gradients, velocities, and stream sizes are believed to be satisfactory for reproduction.

2. Highly variable factors such as temperature and effects of freshets, which cannot be accurately evaluated (in most situations) on the basis of available information, are considered as favorable.

3. Survival of larvae from the nests may be anticipated to be normal.

Streams in which adult sea lampreys were observed or reported (see also table 23):

1950 survey area: 7 (Additional records available from 1951 rechecks will be presented in a later report.)

1951 survey area: none (Most of the streams were examined after the spawning season.)

Streams in which sea lamprey nests were observed or reported (see also table 23):

1950 survey area: 14 (Additional records available from rechecks made in 1951 will be presented in a later report).

1951 survey area: 1

It is probable that nests were present in other streams but were not observed because:

1. The general rarity of nests in the Lake Superior region would make it entirely possible to miss an occasional single nest.

2. The brown color of many streams may have obscured some nests.

3. Nests may have been destroyed in streams examined long after the spawning season.

Streams in which sea-lamprey larvae were obtained (see also table 23):

1950 survey area: 1 (Almost all streams were examined for larvae; lamprey larvae of several species were obtained from 23 streams).

1951 survey area: none (No streams in this area were checked for larvae).

Streams upon which some type of control may eventually be necessary:

1950 survey area: 112

1951 survey area: 136

Tributary streams in this group can be controlled by devices placed on main streams. The need for control on many of these streams can be determined only by future examination.

Stream mileages: Over 1,300 miles of stream were surveyed in 1950; the combined lengths of all streams in the area amount to considerably more than that. The lengths of all streams in the 1951 area aggregate over 1,500 miles, of which several hundred miles were surveyed.

Standards and methods

Criteria used in estimating the productive potentials of Lake Superior basin streams were established during a study of the life history of the sea lamprey by Applegate (1950).

The life history of the sea lamprey in the Great Lakes can be summarized as follows. In the spring the adults ascent streams and spawn on gravel. After a short period of incubation the eggs hatch and the larvae emerge. These larvae, carried downstream by the current, dive for and burrow into the bottom when quiet water is reached. Metamorphosis takes place after a larval life of about 4 years. The resulting sexually immature adults are carried by high water to the lakes where the parasitic life of 12 to 20 months begins.

For successful completion of the stream phases of the life cycle, certain known basic conditions among others must prevail in the streams. Suitable larval habitat consisting of soft (sand or silt) bottom material must be present in the streams proper or in their estuaries. In order to spawn, adult lampreys require (1) water temperatures of about 53° F. or above, (2) water velocities of 1 to 5 feet a second, and (3) the presence of suitable gravel formations (or other hard elements such as clam shells) for nest building (Applegate 1950). These factors were found to be of optimum quality in certain streams when (1) water temperatures were between 60° F. and 70° F.; (2) water velocities ranged from 1 to 3 feet a second; (3) stream-bed formations consisted of concentrated gravel of ideal size (3/4 inch to 3 inches in diameter) in bars or ridges which formed riffle areas. These criteria are based on studies of lampreys in streams flowing into Lakes Huron and Michigan. It is suspected that spawning may be inhibited in many Lake Superior streams by certain conditions which are common in that area, such as colder water temperatures, steep gradients, sudden freshets, and heavy turbidity due to lake clay.

The streams were examined by walking or canoeing along their courses for the distance required to determine their productive potentials; if abundant spawning habitat or an obvious barrier was found in a stream section just above the mouth, examination of that stream was discontinued; streams in which gravel was lacking were surveyed from mouths to headwaters to make certain of the lack.

Standardized methods and techniques were employed so far as it was practical to do so. The necessity for covering a large amount of territory demanded deviation from preferred methods (usually the employment of visual estimates instead of measurements) often enough to warrant an explanation of those actually used in this particular survey.

Stream lengths: Computed from county maps (Michigan Department of Conservation); a correction factor (variable) based on the estimated increase due to meandering, was applied to each computed length.

Stream widths: Average widths were computed from a series of measurements and visual estimates taken at varying distances apart; accurate measurements (steel tape) were made at potential control sites, and at most points where lampreys, nests, and suitable spawning habitat were located. At the beginning of the 1950 survey, the majority of widths were determined by direct measurement. As the season progressed and biologists became more experienced, most widths were determined by visual estimates checked frequently by tape measurements.

Stream depths: Depths were determined at the time widths were recorded. Accurate depth measurements in shallow streams were made with a yardstick. The average depth of a stream at any one point was calculated from measurements at the stream center and at points midway between the center and the edges. Individual depths in deep streams (often turbid) were obtained with a sounding line.

Water velocities: Velocities were determined at the time widths and depths were recorded. At the beginning of the survey, velocities at individual points were taken by the "chip" method (velocity in feet per second was calculated from the time required for a small glass vial half filled with water to float over a measured distance; an average was obtained from three measurements). As the survey progressed, velocities were determined by visual estimates, checked frequently by the chip method. The chip method was impracticable in many small streams because of obstructions.

Water temperatures: Taken with Taylor pocket thermometers to the nearest degree Fahrenheit.

Gradients: Determined by visual estimation, and classified as follows:

Slight: Stream bed appearing to be flat or with slight evidence of gradient.

Steep: Appearing to be approximately 1° or more.

Moderate: Between slight and steep.

Visual estimates were accurate enough for the purposes of this survey. Gradients were noted frequently.

Bottom types: The total amounts of each type were arrived at by visual estimates. Soft bottom was classified as sand, silt, mud, and clay. The presence of hardpan was also noted. Hard bottom was classified as bedrock, boulders (12 inches in diameter and up), rubble (3 inches to 12 inches in diameter), large gravel (3/4 inch to 3 inches in diameter), and small gravel (1/4 inch to 3/4 inch in diameter).

Spawning sites: Gravel deposits were classified as follows (in order of suitability):

1. Concentrated

    a. Gravel bars and ridges on riffles.

    b. Continuously flat, pavement-like formations in riffle areas.

2. Scattered

    a. Patches of large gravel.

    b. Discontinuous, variable amounts of gravel in or upon other substrata.

    c. Gravel mixed with rubble and boulders.

Possible number of nests: A visual estimate was made of the possible number of nests which could be constructed on the gravel formations present.

Barriers: Classified as natural or man-made. Great Lakes sea lampreys cannot ascent smooth perpendicular barriers which are 3 feet or more in height. Their ability to ascend broken and irregular rock formations is greater; they have been observed negotiating a falls 7 feet high, which had a face of irregularly eroded limestone.

Adult lampreys and nests: Locations and numbers of nests were recorded with accompanying notes on type of spawning material, quality of gravel formations, and other factors. The numbers of adult lampreys were recorded in relation to activity (swimming, resting, spawning), condition (unspawned, partially spawned, spent, dying, or dead), and location. Samples of lampreys were collected and preserved.

Larval lampreys: During the 1950 survey, almost all streams were examined at various distances below spawning habitat for larvae, which were collected from all types of habitat by digging. All larvae were preserved for identification. No attempt was made to collect larvae in 1951.

Color of streams: Classified as brown or colorless, by visual examination.

Turbidity of streams: Classified as clear, or slightly, moderately, or heavily turbid.

Water levels: Annual fluctuations were determined by noting high-water marks and condition of stream at time of examination. When possible, the characteristics of individual streams in relation to extent of precipitation were recorded. Special attention was paid to water-level conditions at proposed control sites.

Pollution: Sources of industrial and domestic pollution were noted (visually) and recorded.

General topography and geographical features: Stream banks, flood plains, and the surrounding country were described. General measurements such as heights, widths and contour were recorded. Soil and plant types were noted, although not in great detail. Road conditions, location of power lines, and relative accessibility of streams and proposed control sites were noted.

Location of control sites: Potential control sites were located in most streams which were found to have productive possibilities. Criteria for selecting control sites (for mechanical weirs; barrier dams, and electrical devices) were established during experimentation with various types of control devices (Applegate and Smith 1951). Flora and fauna: Only limited observations were made. Exceptional conditions (for example, extreme abundance of aquatic plants) were noted. A limited amount of seining for fish was done.

Evaluation of streams

For the sake of convenience and simplicity, the entire Michigan watershed of Lake Superior has been divided into 22 areas (figs. 2-23; tables 1-22), each of which is discussed separately.

With each figure and table are brief comments on the area and its streams, factors which may inhibit or prevent spawning in the future, and control possibilities.

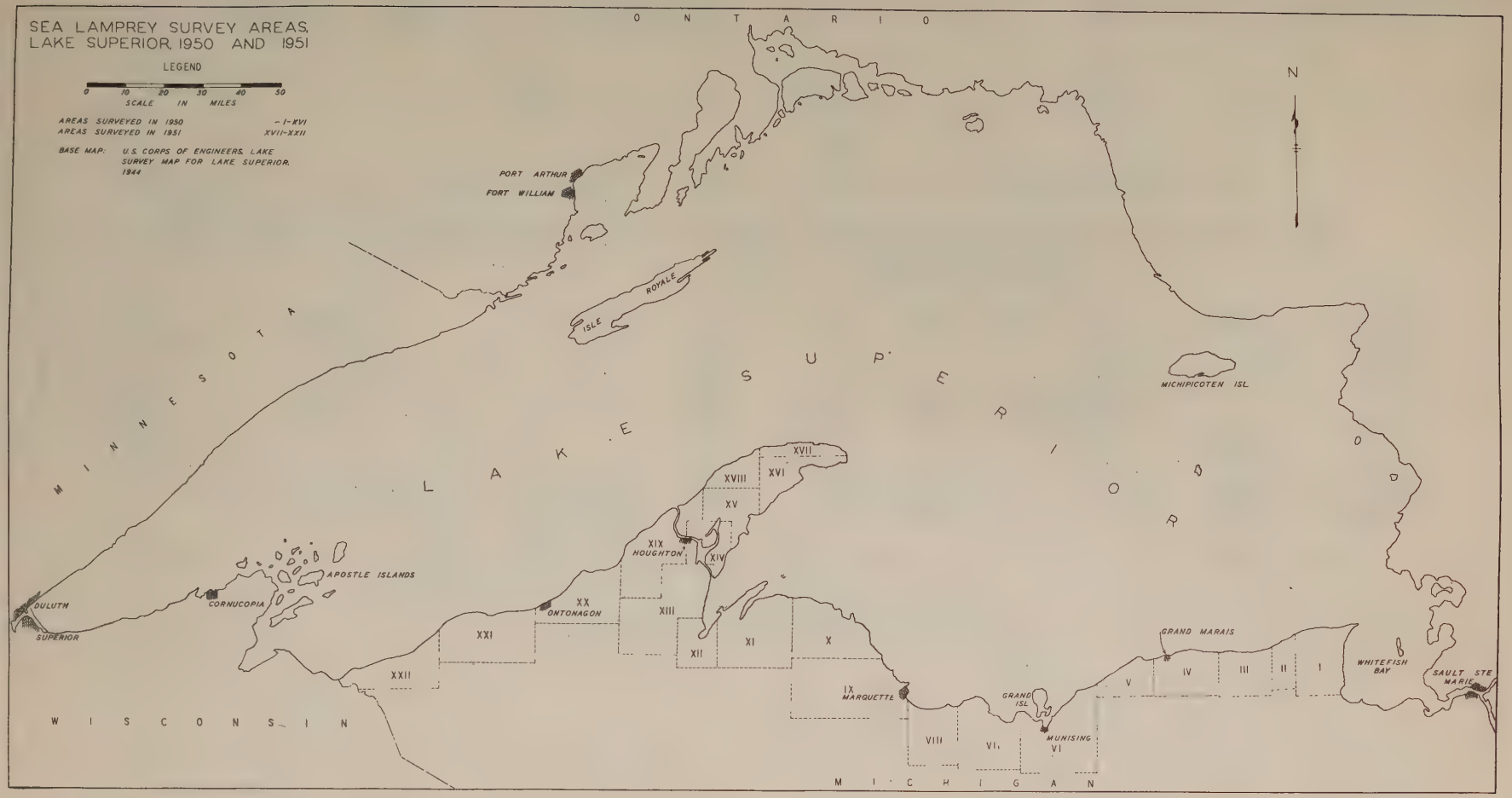

Figure 1.—Lake Superior, showing areas, and their arbitrary subdivisions, surveyed in 1950 and 1951.

Table 1.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 1 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Tahquamenon River	Chippewa, 48-6-14	20.0	300.0	8.0	Slight-moderate	Sluggish-5.0	59-68	6/6-6/29	Medium	Spawning sites, velocity	Electrical
Obriens Creek	Chippewa, 49-6-27	2.0	4.0	1.5	Slight-moderate	Sluggish-2.5	52-68	6/9-7/10	Small	Temperature	Mechanical weir & trap
Betsy River	Chippewa, 49-6-2	42.0	25.0	2.0	Slight	Sluggish-3.0	55-71	6/13-7/10	Large	None	Electrical
Creek # 1	Chippewa, 50-7-1	0.25	6.0	0.5	Slight	1.25	63	6/28	Small	Shifting bottom	Mechanical weir & trap
Vermilion Creek	Chippewa, 50-7-2	0.25	10.0	1.0	Slight	2.0	65	6/26	Medium	Shifting bottom	Mechanical weir & trap
Creek # 2	Chippewa, 50-7-4	0.05	5.0	0.33	Slight	1.25	56-68	6/27-7/2	Small	Shifting bottom	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where barrier dams or field conditions terminated the area usable by sea lampreys short of the headwaters.

3/ Applicable only to the surveyed portion of the stream.

4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

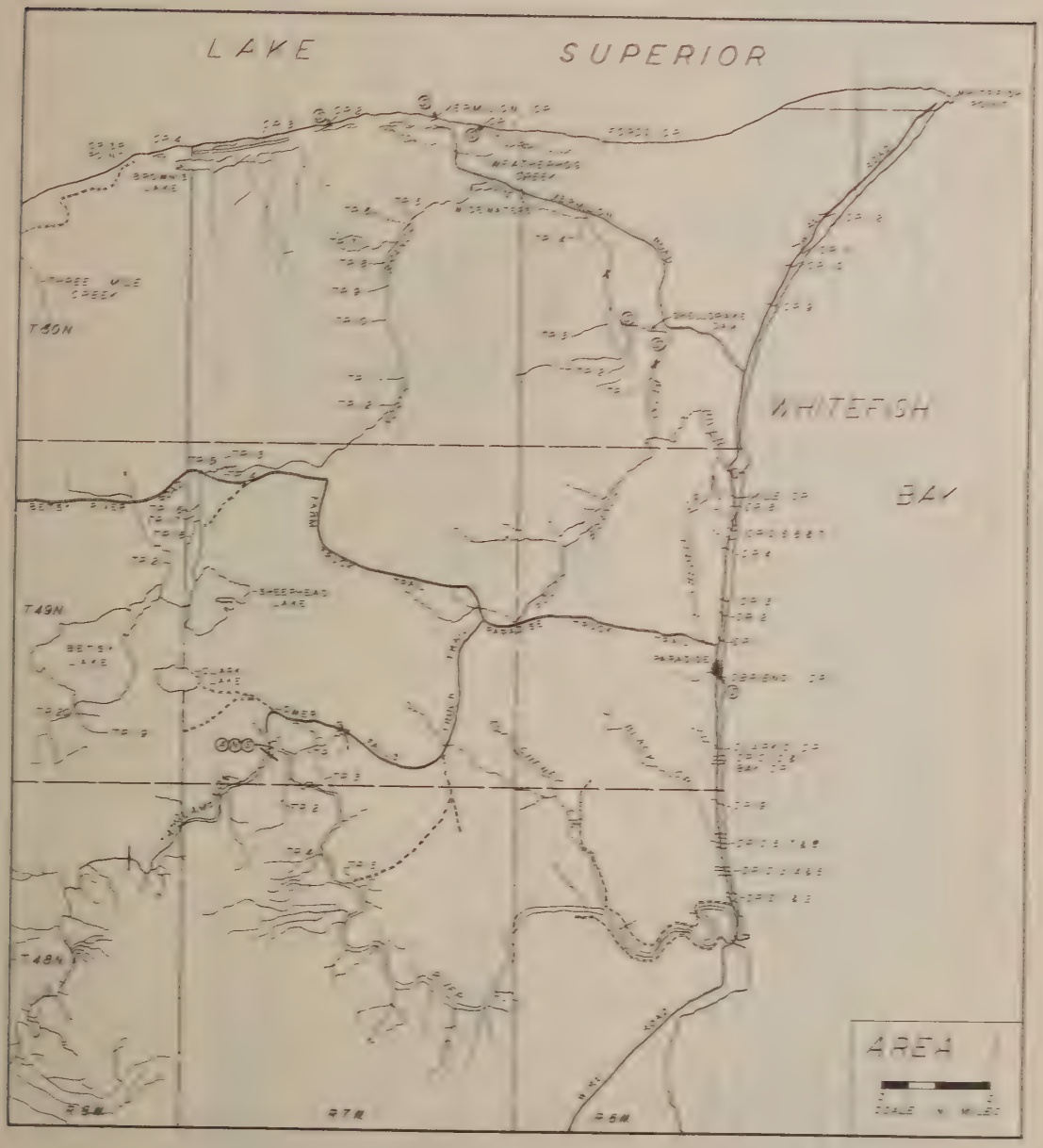

Figure 2.—Area 1.

Description of Area 1 (Fig. 2)

Embraces most of the western portion of Chippewa County, Mich., and contains a few large and numerous small coastal streams. Adult sea lampreys and nests were observed only in the Tahquamenon River just below the Lower Falls. Limited potential spawning habitat is present at that point and near the mouths of four small coastal streams (table 1). Potential spawning habitat is present to a greater extent in portions of the North Branch of the Betsy River. The Tahquamenon River is much too large for mechanical control devices; an electrical control device is recommended. Although it is much smaller, the Betsy River presents a similar problem. Creeks Nos. 1 and 2 are relatively inaccessible. All but a very few of the streams are brown in color, of relatively low velocity, and sandy-bottomed. Most of them drain extensive bogs and swamps, and flow through thick tag alder flood plains. The soil, which is generally sandy and poor, supports a jackpine - white pine - popple climax type. Topography is gentle.

Table 2.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 2 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Three Mile Creek	Luce, 50-8-16	5.0	8.0	0.66	Slight	0.75-1.25	50-54	7/2-7/3	Medium	Spawning sites, temperature, velocity	Mechanical weir & trap
Little Two Hearted R.	Luce, 50-9-24	32.0	20.0	2.0	Slight	1.0-2.0	53-76	7/4-7/8	Medium	Spawning sites, shifting bottom, temperature	Electrical

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

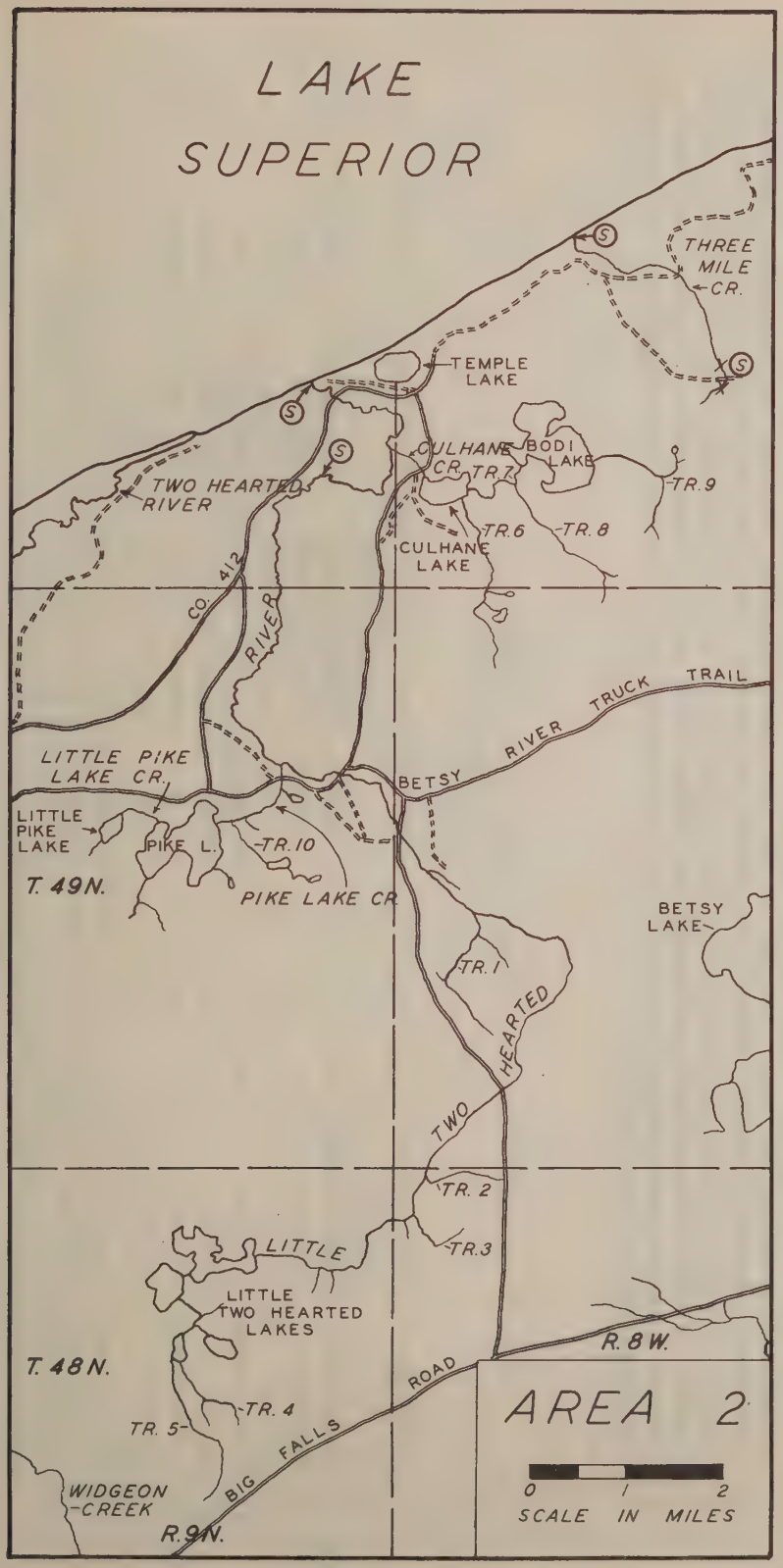

Figure 3.—Area 2.

Description of Area 2 (Fig. 3)

Embraces a portion of eastern Luce County, Mich., and contains only two streams and their tributaries. No adult sea lampreys or nests were observed, but both main streams contained potential spawning habitat. The Little Two Hearted River is probably too large for practical mechanical control, and an electrical device is recommended. The streams in the area are generally brown in color, of relatively low velocity, and sandy-bottomed; they flow through flood plains covered with a dense growth of tag alder. The soil is sandy and poor, and the forest climax type is predominantly coniferous. The topography is low and accordingly much of the area consists of bogs and swamps.

Table 3.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 3 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Two Hearted River	Luce, 50-9-27	10.0	50.0	4.0	Slight	1.0-3.0	53-68	7/11-7/13	Large	Temperature	Electrical
E. Br. Two Hearted R.	Luce, 50-10-1	25.0	25.0	1.5	Slight	Sluggish-3.0	51-72	7/11-7/22	Large	Temperature	5/
W. Br. Two Hearted R.	Luce, 49-9-6	50.0	30.0	3.0	Slight-moderate	1.3	53-65	7/13-7/31	Large	Temperature	5/
Dawson Creek	Luce, 49-10-29	20.0	15.0	1.0	Slight-moderate	Sluggish-2.25	56-61	7/25-7/26	Large	Temperature	5/
N. Br. Two Hearted R.	Luce, 48-11-1	30.0	10.0	0.66	Slight	Sluggish-1.0	57-65	7/28-8/3	Medium	Temperature	5/
Dead Sucker River	Luce, 50-11-34	8.0	20.0	1.0	Slight	Sluggish-2.5	56-65	8/5	Medium	Velocity	Electrical

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distence plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

3/ Applicable only to the surveyed portion of the stream.

4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

5/ Stream tributary to another upon which it would be more practical to place a control device.

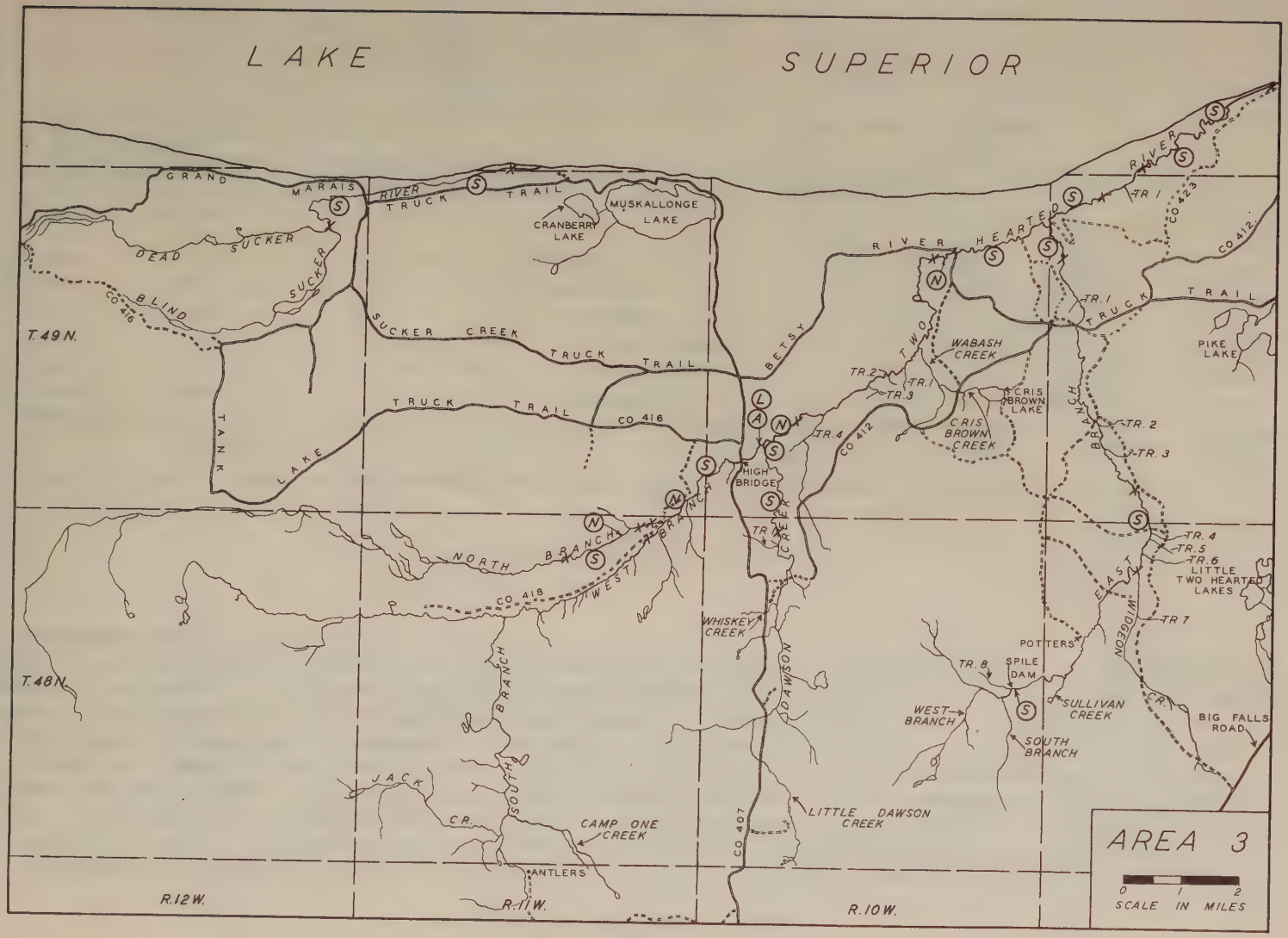

Figure 4.--Area 3.

Description of Area 3 (Fig. 4)

Embraces the northern portion of western Luce County, Mich., and contains only two streams, both of which are large. Limited amounts of potential spawning habitat are present in the Dead Sucker River. Unlimited facilities for spawning are present throughout much of the Two Hearted River system; several adults, larvae, and over 60 nests were observed in 1950 in this watershed. Both streams are too large for practical mechanical control devices; electrical devices are recommended. The Dead Sucker River is clear and of relatively low velocity; it drains an extensive low area of bogs and swamps. The streams of the Two Hearted River system are brown in color and of moderate water velocity; they flow through flood plains covered with dense stands of tag alder and drain extensive bogs and swamps. The topography is low. The soil is sandy and poor and accordingly the forest climax type is predominantly coniferous.

Table 4.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 4 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Sucker River	Alger, 49-13-4	30.0	25.0	1.0	Slight-moderate	1.0-5.0	52-65	8/7-8/18	Large	Velocity, temperature	Electrical
Baker Creek	Alger, 49-13-4	7.0	10.0	0.66	Slight	0.75-1.0	---	---	Small	Spawning sites, temperature	Mechanical weir & trap
Creek # 1	Alger, 49-13-5	0.3	1.5	0.12	Slight-moderate	1.0-2.0	59-67	8/9	Small	Temperature, gradients	Mechanical weir & trap
Creek # 3	Alger, 49-13-6	0.75	5.0	0.16	Slight-moderate	1.0	57-60	8/9	Small	Temperature, gradients	Mechanical weir & trap
Creek # 4	Alger, 49-13-6	0.3	1.0	0.08	Slight-moderate	0.5	55	8/9	Small	Width, depth, temperature	Mechanical weir & trap
Sable Creek	Alger, 49-14-2	0.5	15.0	1.0	Slight-moderate	1.25-2.0	64	8/9	Medium	Spawning sites, velocity, temperature	Electrical

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

3/ Applicable only to the surveyed portion of the stream.

4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

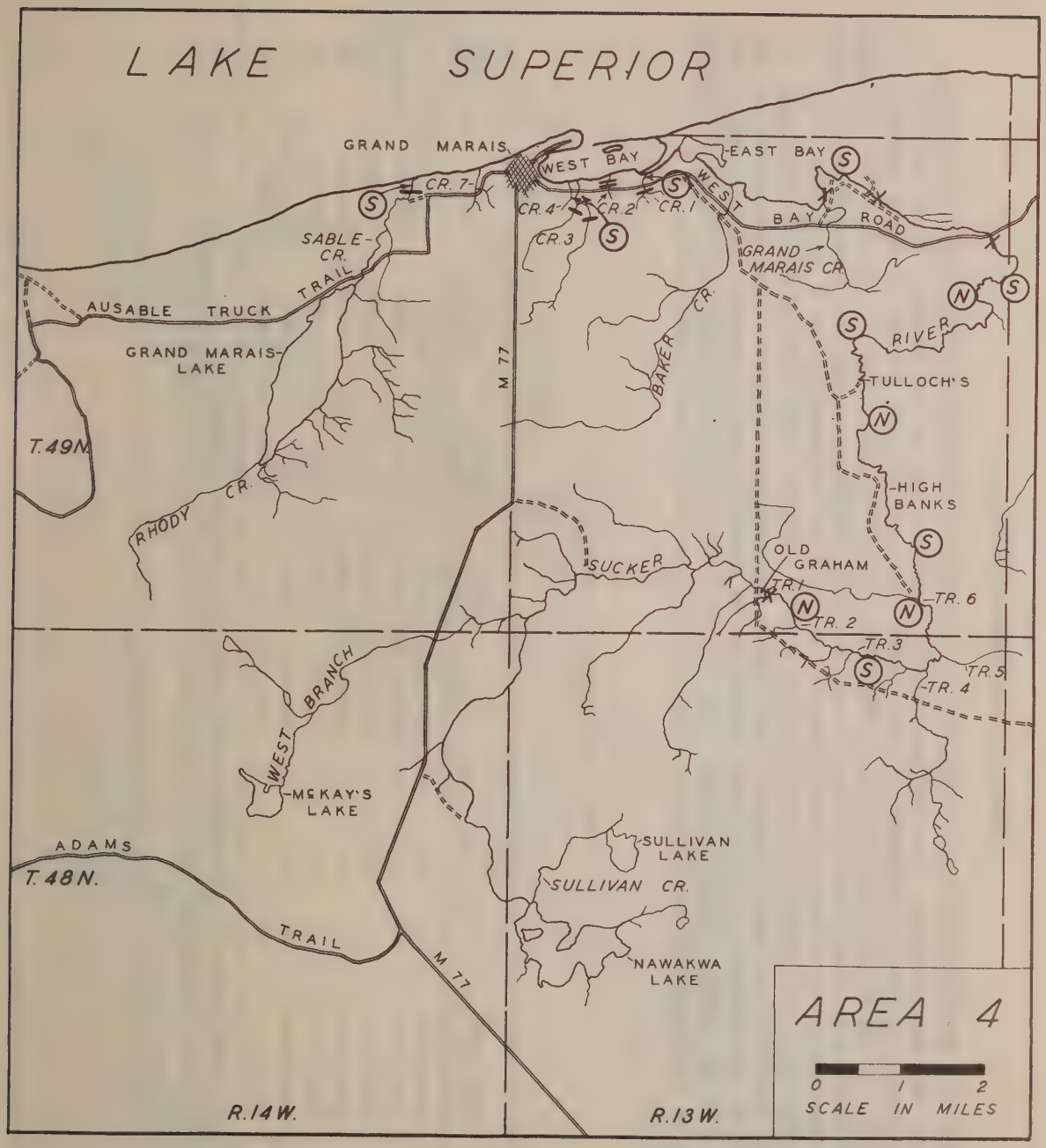

Figure 5.—Area 4.

Description of Area 4 (Fig. 5)

Embraces the northeast portion of Alger County, Mich., and contains six streams which are accessible to the sea lamprey. Sea lamprey nests were observed in the Sucker River in 1950. Extensive spawning habitat is present in that river and to a limited extent in Baker Creek, Creeks Nos. 1, 3, and 4, and Sable Creek. The Sucker River is too large for a practical mechanical control device; an electrical device is recommended. Mechanical control devices can be constructed in the remaining streams, but fluctuations in water volumes may be a problem. The streams in the area are generally brown in color and of moderate velocity; they flow through flood plains covered with heavy stands of tag alder, hardwoods and cedar. The topography is, as a rule, gentle; an exception is the steep shoreline of former glacial Lake Nipissing, just south of West Bay and the mouth of Sable Creek. The soil is sandy and poor, and accordingly the forest climax type is predominantly coniferous. Much of the area is cut and burned over.

Table 5.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 5 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Hurricane Creek	Alger, 49-15-3	12.0	20.0	1.0	Slight-steep	1.0-5.0	---	---	Large	Velocity, gradient, and temperature	Mechanical weir & trap
Sullivan Creek	Alger, 49-15-9	6.0	5.0	0.58	Slight-moderate	1.0-4.0	---	---	Medium	Temperature	Mechanical weir & trap
Seven Mile Creek	Alger, 49-16-25	10.0	20.0	1.0	Slight-moderate	Sluggish-3.0	---	---	Large	Temperature	Mechanical weir & trap
Lowney Creek	Alger, 49-16-17	3.0	15.0	1.0	Slight-moderate	Sluggish-1.0	50	9/10	Medium	Temperature	5/
Tributary # 7	Alger, 48-16-17	4.0	6.0	0.5	Slight	1.25	56	9/10	Medium	Temperature	5/
Tributary # 6	Alger, 48-16-13	3.5	6.0	0.25	Slight-steep	1.0-2.0	54	9/4	Medium	Gradient, velocity, temperature	5/
Tributary # 5	Alger, 48-17-13	3.5	4.0	0.5	Slight-moderate	0.75-1.0	49-55	9/10	Small	Temperature	5/

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

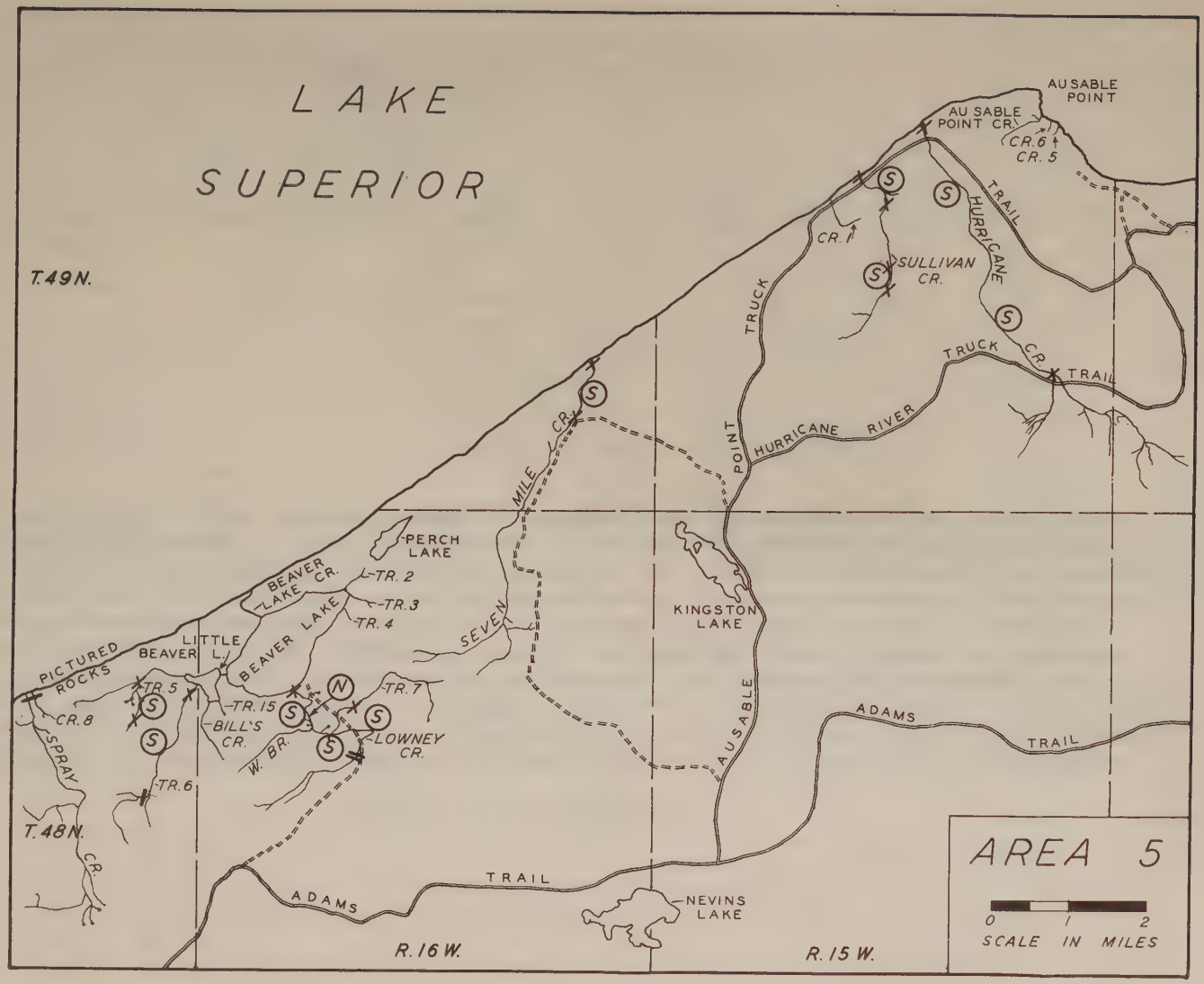

Figure 6.—Area 5.

Description of Area 5 (Fig. 6)

Embraces the north-central portion of Alger County, Mich., and contains at least seven streams in which spawning facilities are accessible to upstream migrants (table 5). Mechanical control devices can be constructed in Hurricane, Sullivan, and Seven Mile Creeks. The latter is relatively inaccessible. Migrations to the streams of the Beaver Lake watershed can be controlled by a device in Beaver Lake Creek; most of the streams in this system are relatively inaccessible. Stream gradients are slight to steep and water velocities vary accordingly. Beaver Lake Creek is interesting in that it forms an exact line of demarcation between the low, sandy country extending east to the Tahquamenon River and the more rugged sandy-loam country (often overlying bedrock) which is predominant to the west. Gradients are steep and velocities are higher in many of the western streams. Hardwoods are predominant on the better soils

Table 6.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 6 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Chapel Lake Creek	Alger, 48-17-21	1.0	18.0	2.0	Slight-moderate	Sluggish-1.0	58	9/11	Medium	Scouring at mouth, partial barrier, temperature	Mechanical weir & trap
Tributary # 13	Alger, 48-17-28	0.25	20.0	0.33	Slight-steep	1.0-3.0	---	---	Small	Gradient, velocity, temperature	5/
Tributary # 16	Alger, 48-17-29	2.0	4.0	0.33	Slight-steep	Sluggish-3.0	48-50	9/14	Medium	Gradient, velocity, temperature	5/
Mosquito River	Alger, 48-18-25	3.0	15.0	0.5	Slight-steep	1.0-3.0	53	9/14	Large	Velocity, temperature	Mechanical weir & trap
Tributary # 17	Alger, 48-18-31	0.25	5.0	0.12	Slight-moderate	1.0-3.0	51	9/14	Small	Velocity, temperature	5/
Miners River	Alger, 47-18-3	4.0	15.0	0.5	Slight-moderate	0.75-1.25	50-60	9/7-9/8	Large	Temperature	Mechanical weir & trap
Creek # 22	Alger, 47-18-30	0.75	2.0	0.08	Slight-steep	0.75-1.25	46-50	9/16-9/18	Small	Gradient, velocity, temperature	Mechanical weir & trap
Creek # 23	Alger, 47-19-36	0.25	2.0	0.08	Slight-steep	0.75-1.25	46	9/16	Small	Gradient, velocity, temperature	Mechanical weir & trap
Creek # 24	Alger, 47-19-36	0.25	2.0	0.08	Slight-steep	0.75-1.25	48	9/16	Small	Gradient, velocity, temperature	Mechanical weir & trap
Creek # 25	Alger, 47-19-36	0.5	4.0	0.33	Slight-moderate	Sluggish-0.75	51	9/16-9/18	Small	Gradient, velocity, temperature	Mechanical weir & trap
Creek # 26	Alger, 46-19-1	0.5	2.0	0.16	Slight-steep	0.75-1.25	46-50	9/16-9/18	Small	Gradient, velocity, temperature	Mechanical weir & trap
Creek # 27	Alger, 46-19-1	0.25	3.0	0.25	Slight-steep	0.75-1.25	46-48	9/16-9/18	Small	Gradient, velocity, temperature	Mechanical weir & trap
Anna River	Alger, 46-19-2	10.0	10.0	1.0	Slight	0.75-2.0	46-50	9/16-9/28	Medium	Temperature	Electrical
Wagner Creek	Alger, 46-19-11	0.3	10.0	0.25	Slight-steep	1.0-3.0	50	9/16	Medium	Gradient, velocity, temperature	5/
Furnace Creek	Alger, 47-19-29	0.75	12.0	1.0	Slight-moderate	Sluggish-3.0	54	9/19	Large	Temperature, velocity	Electrical
Gongeau Creek	Alger, 47-19-29	4.0	6.0	0.5	Slight-steep	0.75-2.0	51-52	9/28-9/30	Medium	Temperature, velocity	5/
Hanson Creek	Alger, 47-19-29	6.0	10.0	0.5	Slight-steep	Sluggish-2.0	50-53	9/20	Medium	Gradient, velocity, temperature	5/
Tributary # 5	Alger, 47-20-25	0.3	2.0	0.04	---	0.75-1.0	48-49	9/20	Small	Temperature	5/
Creek # 6	Alger, 47-19-19	2.0	2.0	0.25	Slight	Sluggish	51	9/19	Small	Temperature	Mechanical weir & trap
Creek # 7	Alger, 47-19-18	0.75	4.0	0.33	Slight	Sluggish-0.75	53	9/18	Small	Temperature, dry stream bed	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

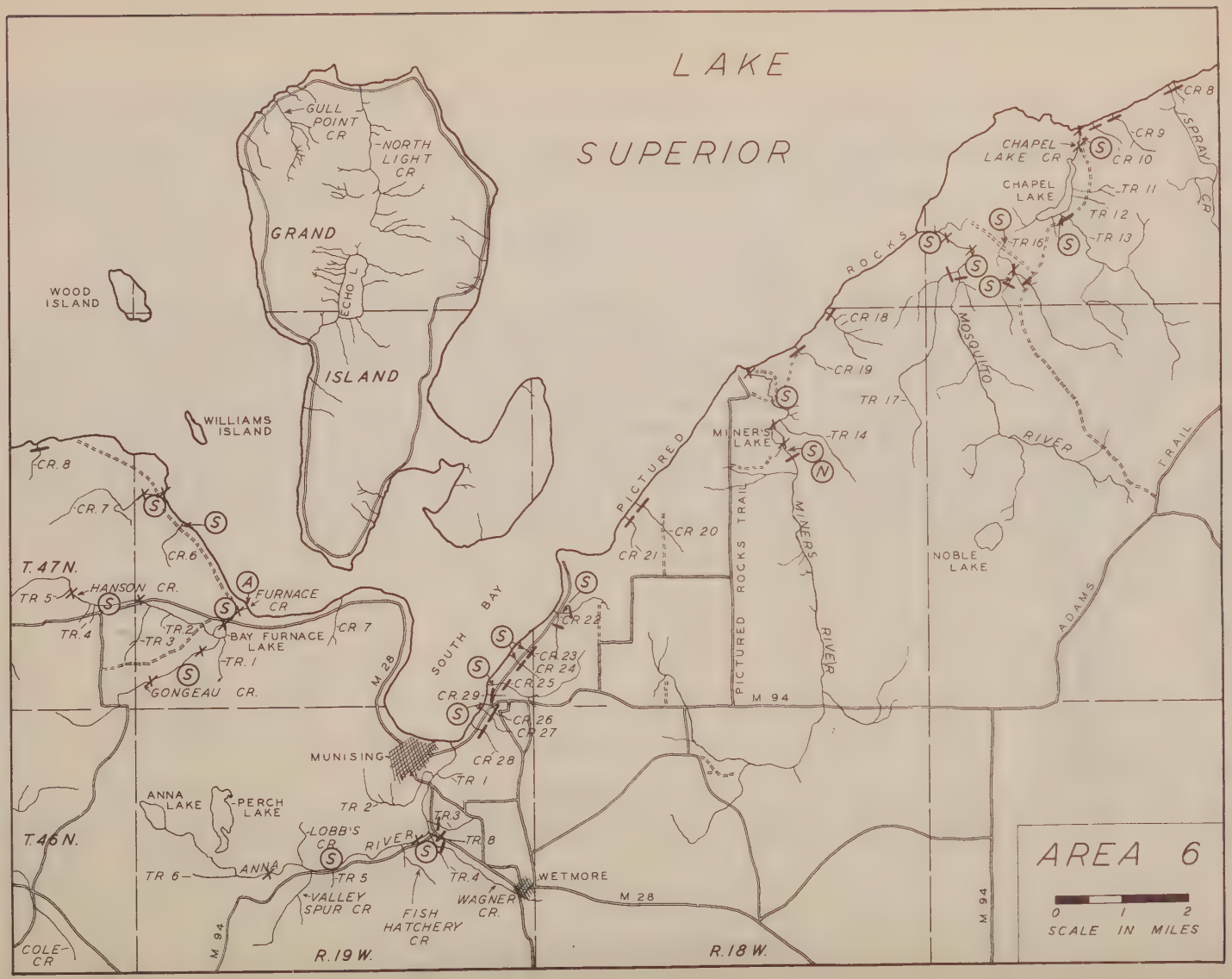

Figure 7.—Area 6.

Description of Area 6 (Fig. 7)

Embraces a portion of northwestern Alger County, Mich., and contains at least one stream which was utilized by sea lampreys in 1950. Nests were observed in Miner's River; dead adults were observed at the mouth of Furnace Creek. Both streams have a large productive potential; a mechanical weir is recommended for Miner's River and an electrical device for Furnace Creek. Fifteen other streams contain spawning facilities. Chapel Lake Creek and the Mosquito River are relatively inaccessible. The streams of the area are both clear and brown in color; gradients range from slight to steep and velocities vary accordingly. The bottoms of several streams are irregular due to the presence of rubble, boulders, and bedrock. The topography of the area is relatively rugged. The sandy-loam soil overlies a bedrock substratum. Hardwoods are predominant. Grant Island which lies off the shore of Area 6 has not been examined.

Table 7.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 7
(Survey made in 1950)

Name of stream [1]	County, township line, range, and section no. at mouth	Length of stream in miles [2]	Average width of stream in ft. [3]	Average depth of stream in ft. [3]	Range in gradient [3]	Range in velocity in ft./sec. [3]	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible [4]
Creek # 10	Alger, 47-20-28	0.1	5.0	0.25	Slight-steep	Sluggish-1.0	---	---	Small	Gradient, velocity	Electrical
Au Train River (lower)	Alger, 47-20-29	10.0	100.0	3.0	Slight	Sluggish	59	9/30	Medium	None	[5]
Joel's Creek	Alger, 47-20-32	6.0	6.0	0.5	Slight-steep	1.0-2.25	51-52	9/27-9/28	Medium	Gradient, temperature	[5]
Cole Creek	Alger, 46-20-8	9.0	7.0	0.5	Slight	0.75	48-51	9/22	Medium	Temperature	[5]
Buck Bay Creek	Alger, 46-20-8	4.0	12.0	0.5	Slight-moderate	0.75	48	9/22	Small	Temperature	[5]
Tributary # 4	Alger, 46-20-16	?	5.0	0.33	---	1.0	48	---	Small	Temperature	[5]
Addis Creek	Alger, 46-20-18	3.0	10.0	0.33	Slight	1.0-1.25	48	---	Medium	Temperature	[5]
Au Train R. (upper)	Alger, 46-20-18	6.0	25.0	Varies	---	Varies	47	10/4	?	Water level fluctuations	[5]
Rock River	Alger, 47-21-15	22.0	20.0	0.66	Slight-moderate	1.0-1.25	53	9/21	Large	Temperature, velocity	Electrical
Nelson Creek	Alger, 47-21-22	6.0	4.0	0.25	Slight	0.75-1.0	47	10/8	Medium	Temperature	[5]
Tributary # 1	Alger, 47-21-27	3.0	3.0	0.5	Slight-moderate	1.0	---	---	Small	Temperature, size	[5]
Tributary # 2	Alger, 47-21-27	6.0	4.0	0.25	Slight-moderate	1.0	---	---	Small	Temperature, size	[5]
Silver Creek	Alger, 46-21-15	10.0	8.0	0.5	Slight-moderate	0.75-1.0	47	10/7	Medium	Temperature	[5]
Tributary # 7	Alger, 47-21-18	1.0	15.0	0.5	Slight-steep	Sluggish	---	---	Small	Gradient, velocity, temperature	[5]
Tributary # 8	Alger, 47-21-18	1.5	15.0	0.5	Moderate-steep	Sluggish	---	---	Small	Gradient, velocity, temperature	[5]
Laughing Whitefish R.	Alger, 48-22-26	30.0	20.0	1.0	Slight-moderate	Sluggish-4.0	47-55	9/21-10/6	Large	Gradient, temperature	Electrical

[1] List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
[2] "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
[3] Applicable only to the surveyed portion of the stream.
[4] From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
[5] Stream tributary to another upon which it would be more practical to place a control device.

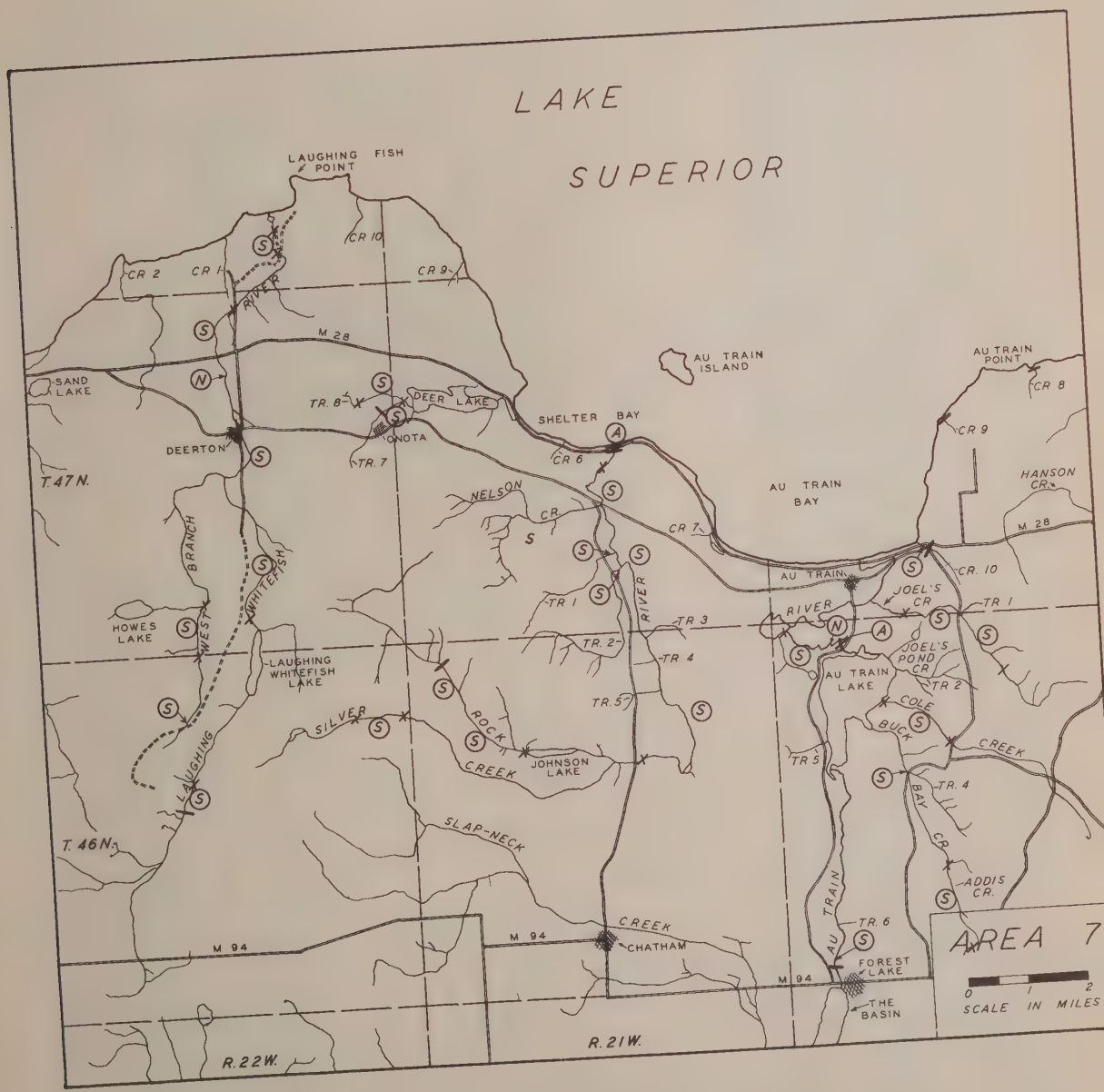

Figure 8.--Area 7.

Description of Area 7 (Fig. 8)

Embraces part of the northwestern portion of Alger County, Mich., and contains at least two streams which were utilized by sea lampreys in 1950. Nests were observed in the Au Train and Laughing Whitefish Rivers. Adult sea lampreys were seen in the Au Train and at the mouth of the Rock River. These three rivers are too large for practical mechanical control; electrical devices are recommended. Spawning facilities are present in 13 other streams, but, at present, control devices (mechanical) need be placed only in Creek No. 10 and Deer Lake Creek. The streams of the area are both clear and brown in color and gradients range from slight to steep. The bottoms of several streams are irregular due to the presence of rubble, boulders, and bedrock. The typography of the area is relatively rugged. The sandy-loam soil overlies a bedrock substratum. Hardwoods predominate.

Table 8.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 8 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperatures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Sand River	Alger, 47-22-6	20.0	33.0	1.0	Slight	0.25-1.75	52	10/7/50	Medium	Temperature, velocity	Electrical
E. Br. Sand River	Marquette, 47-23-35	9.25	6.0	0.33	Slight	1.75	52	10/7/50	Small	Temperature, obstacles	5/
Chocolay River	Marquette, 47-24-6	23.0	46.0	1.0	Slight	1.0-2.5	44-67	6/6-9/25/50	Large	Level fluc., temperature ?	Electrical
E. Br. Chocolay River	Marquette, 46-24-14	3.3	22.5	0.9	Moderate	1.5	51-52	9/14,15/50	Medium	Temperature, level fluc.	5/
W. Br. Chocolay River	Marquette, 46-24-14	4.0	20.0	0.9	Slight-steep	1.5-2.25	54-56	8/24/50	Small	Obstacles, temperature	5/

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

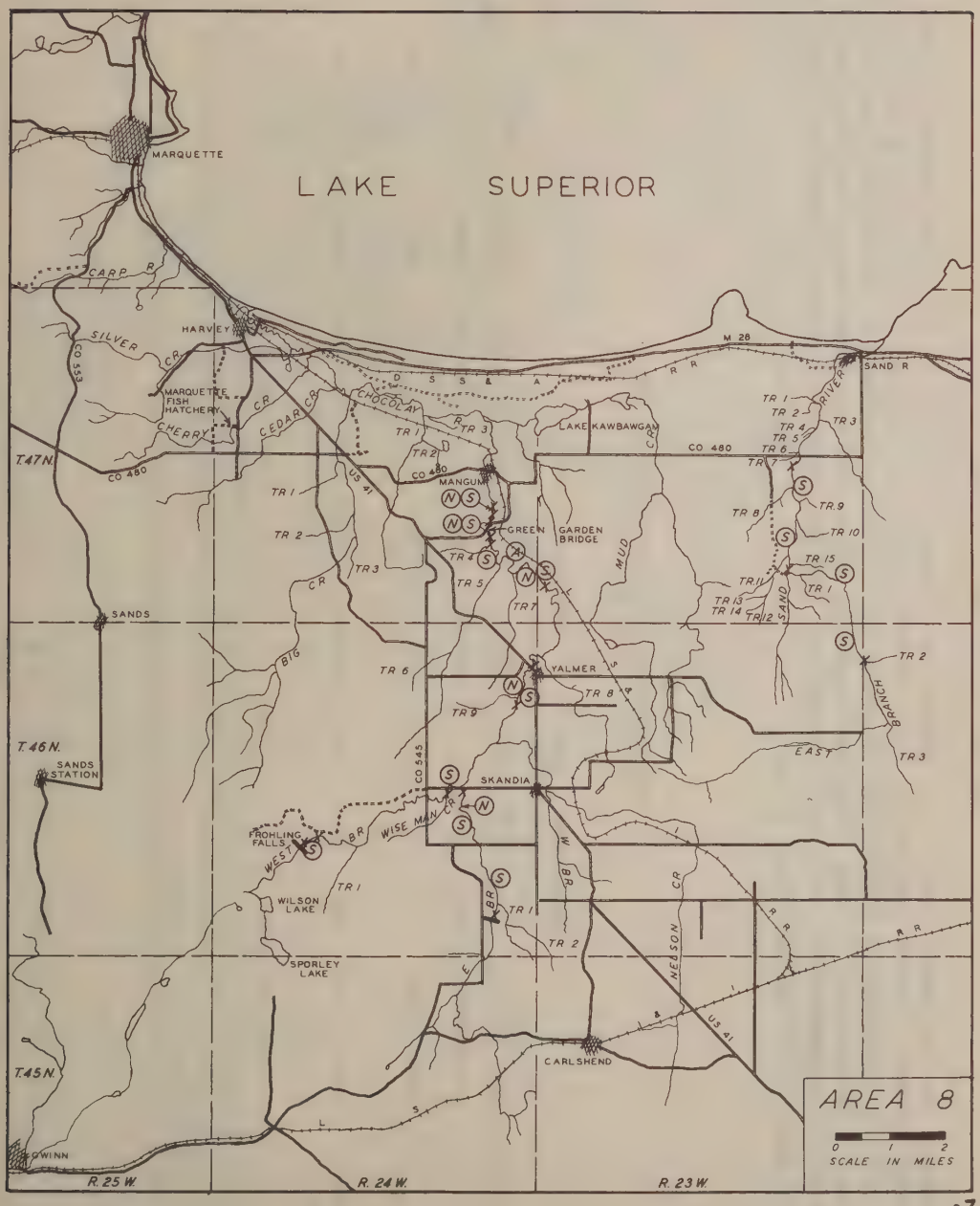

Figure 9.--Area 8

Description of Area 8 (Fig. 9)

Embraces the northeast portion of Marquette County, Michigan, and the watersheds of the Sand and Chocolay Rivers. Nests and adults were observed in considerable numbers in the Chocolay; both streams contain appreciable amounts of spawning facilities. Control by electrical devices is recommended. The streams of the area are brown in color and gradients range from slight to steep. The area is characterized by rolling to rugged topography, sandy to gravely moraines, fairly rich soils, and mixed northern hardwood forest.

Table 9.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 9 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Carp River	Marquette, 48-25-36	10.0	37.5	0.9	Slight-steep	0.5-2.5	44-45	10/5	Medium	Level fluc., temperature, pollution	Electrical
Harlow Creek	Marquette, 49-25-20	13.0	15.0	0.5	Slight-moderate	Up to 1.0	57	9/30	Small	Spawning sites, velocity, obstacles	Mechanical weir & trap
Bismark Creek	Marquette, 49-26-24	8.5	15.0	0.5	Slight-steep	2.25	58	10/1	Medium	Spawning sites, obstacles	5/
Little Garlic River	Marquette, 49-26-2	8.0	17.5	0.5	Slight-steep	1.0-1.75	55-57	9/30	Medium	Spawning sites	Mechanical weir & trap
Big Garlic River	Marquette, 50-26-21	13.0	20.0	0.75	Slight	0.9-1.5	59	10/2	None	Spawning ma-terials, barrier falls	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus a plication of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

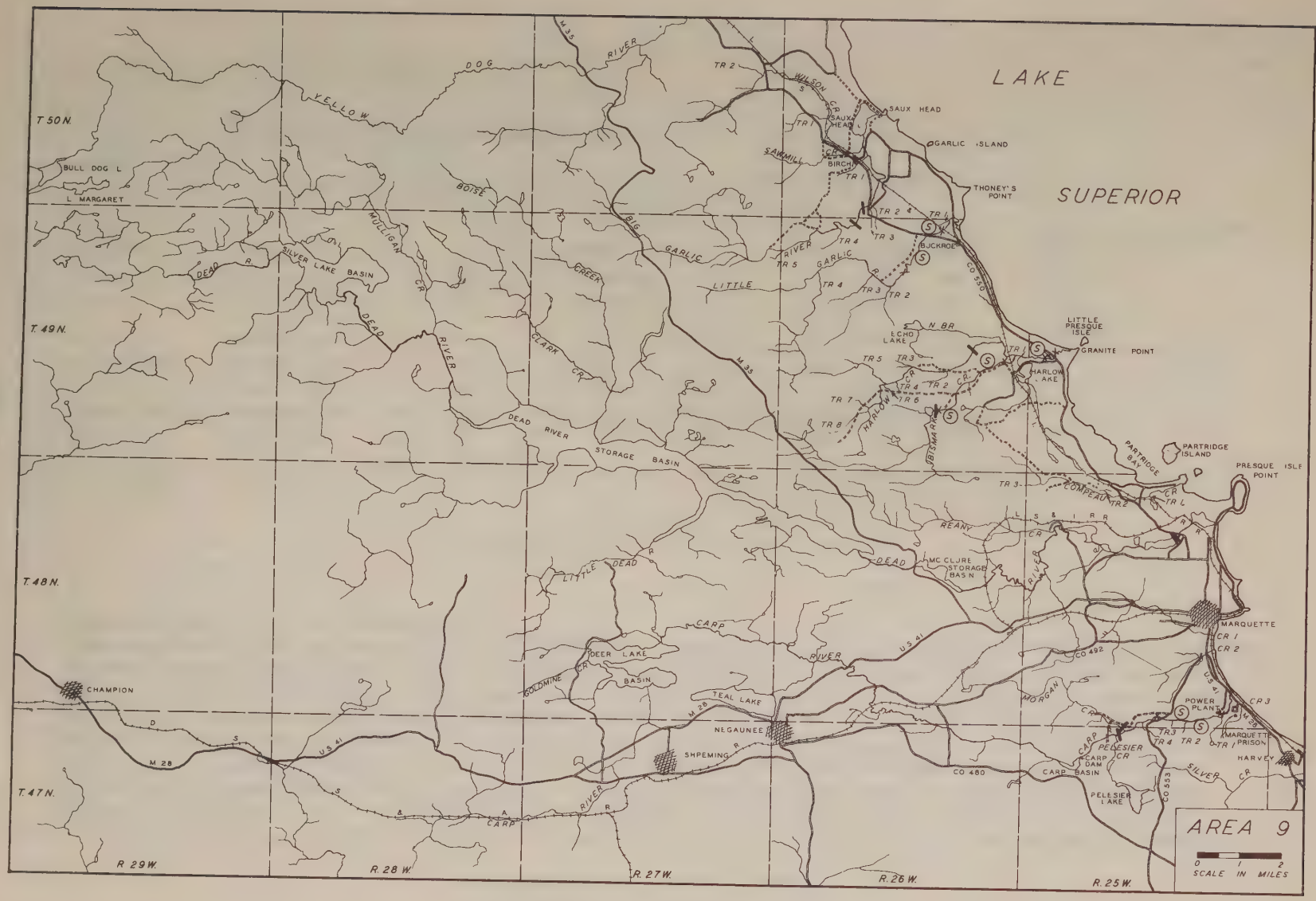

Figure 10.---Area 9.

Description of Area 9 (Fig. 10)

Embraces the north central portion of Marquette County, Mich., and includes the Carp, Dead, Big Garlic, and Little Garlic Rivers, Harlow and Compeau Creeks, and several small coastal streams tributary to Lake Superior. All of these streams except the Dead River, with a barrier near its mouth, are potential lamprey producers but no evidence of utilization was observed. Electrical control devices are recommended for the Carp and Big Garlic, and mechanical structures for the other potentially productive streams. The streams in the area are generally clear and brown (the Carp tends to be turbid and polluted in the lower reaches). Gradients range from slight to steep. Hard bottom constituents in many forms are abundant. Rugged, rocky hill and moraine topography predominates except in the narrow coastal sand plain; soils are light to heavy sandy loams over bedrock. Northern hardwoods are predominant.

Table 10.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 10 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperatures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Iron River	Marquette, 51-26-18	3.0	60.0	1.5	Slight	1.5	60	9/28/50	Small	Spawning sites	Electrical
Salmon Trout River	Marquette, 52-27-32	12.0	31.0	1.0	Slight-steep	1.0-2.5	51-54	9/27,28/50	Medium	Temperature	Mechanical weir & trap
Pine River	Marquette, 52-28-21	3.0	30.0	1.5	Slight	1.0-2.0	56	9/27/50	Medium	Spawning sites, temperature, and velocity	Electrical
Rush Creek	Marquette, 52-28-20	1.0	7.0	0.25	Slight	Up to 1.0	58	9/26/50	Small	Obstacles, velocity	5/
Mountain Stream	Marquette, 52-28-29	1.6	10.5	0.5	Moderate-steep	2	57	9/26/50	Medium	Obstacles, temperature	5/
Little Huron River	Marquette, 52-29-17	7.0	9.0	0.5	Slight-moderate	1.5-1.75	43-44	9/24/50	Medium	Spawning sites, temperature, obstacles	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

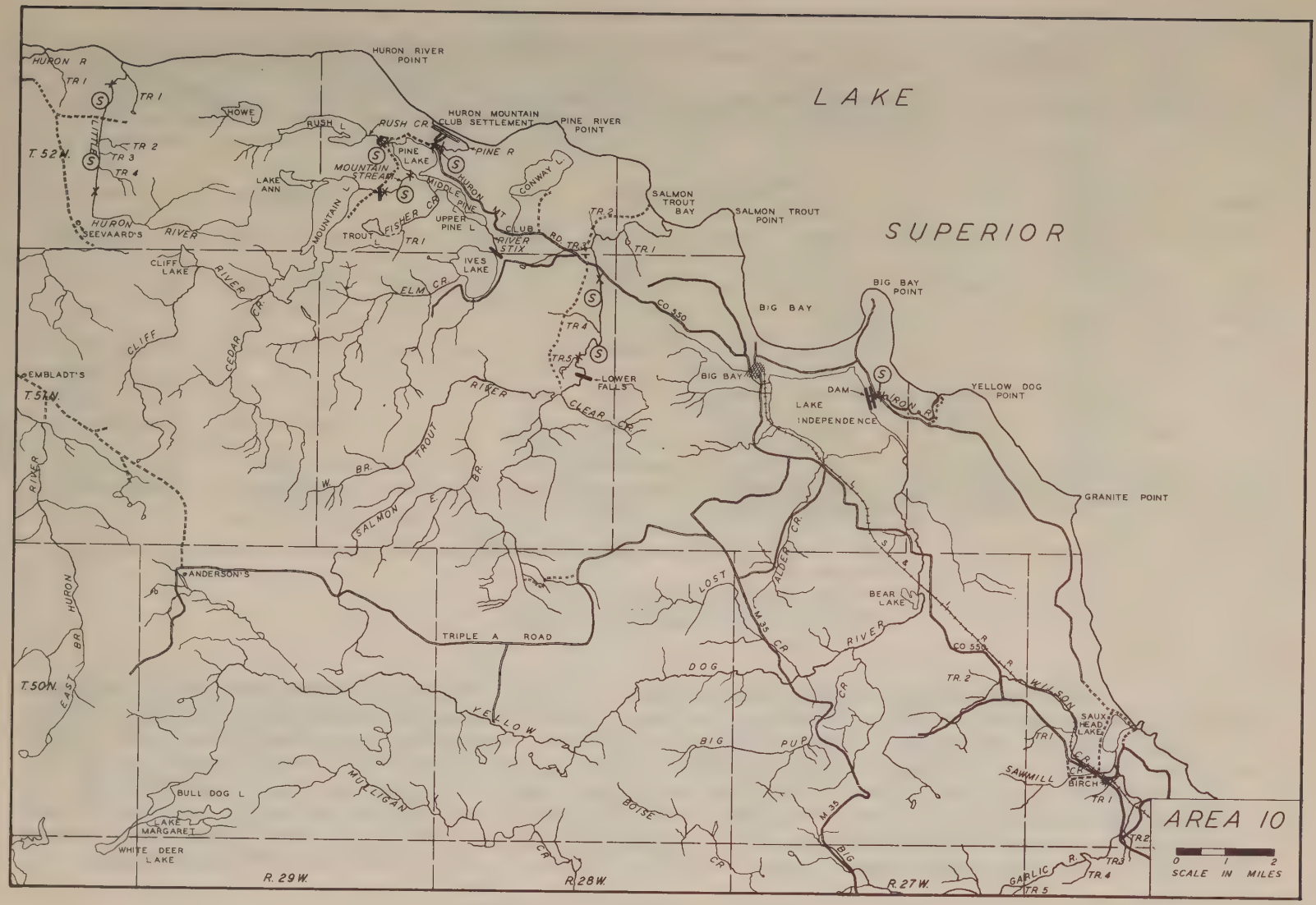

Figure 11.—Area 10.

Description of Area 10 (Fig. 11)

Embraces the northwestern portion of Marquette County, Mich., and contains the Yellow Dog-Iron, Salmon Trout, Pine, and Little Huron River watersheds. All have recognizable productive potentials but no evidence of past or present utilization exists. Electrical control devices are recommended for the Yellow Dog-Iron system and the Pine; mechanical structures are suitable for the Salmon Trout and Little Huron. Clear, organically brown streams typify the area. Gradients range from slight to steep. Hard-bottom materials are common but soft constituents occur frequently. Rugged, rocky mountainous wilderness characterizes the area. Morainic slopes and ridges occur commonly; soils are relatively rich, and overlay bedrock. Northern hardwoods and mixed growth predominate.

Table 11.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 11 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Huron River	Marquette, 52-29-18	12.0	31.5	1.0	Slight-steep	1.5-1.75	48-51	9/23	Medium	Temperature, level fluctuations, obstacles	Electrical
E. Br. Huron River	Baraga, 52-30-35	4.75	25.0	0.33	Moderate-steep	2.0	48	9/21	Medium	Temperature, level fluctuations, obstacles	5/
Trib. # 1 to E. Br. Huron River	Baraga, 51-30-1	2.5	10.0	0.33	Slight-moderate	1.75	48	9/21	Small	Temperature, spawning sites	5/
W. Br. Huron River	Baraga, 52-30-35	5.0	12.0	0.66	Moderate	2.0	---	---	Medium	Level fluctuations, temperature, obstacles	5/
Ravine River	Baraga, 51-31-4	10.0	21.5	0.5	Moderate-steep	0.75-2.0	62	8/31	Large	Level fluctuations	Mechanical weir & trap
W. Br. Ravine River	Baraga, 51-31-2	6.75	6.0	0.75	Moderate-steep	2.0- ?	---	---	Small	Spawning sites, level fluctuations, temperature, obstacles	5/
Slate River	Baraga, 51-31-8	1.0	15.0	0.5	Slight-steep	0.5-1.75	59-63	8/31 & 9/12	Medium	Spawning sites, level fluctuations, barriers	Electrical
Silver River	Baraga, 51-31-18	13.0	45.0	0.5	Moderate-steep	1.0-1.75	54	8/31	Medium	Spawning sites, fluctuations, temperature, obstacles	Electrical

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
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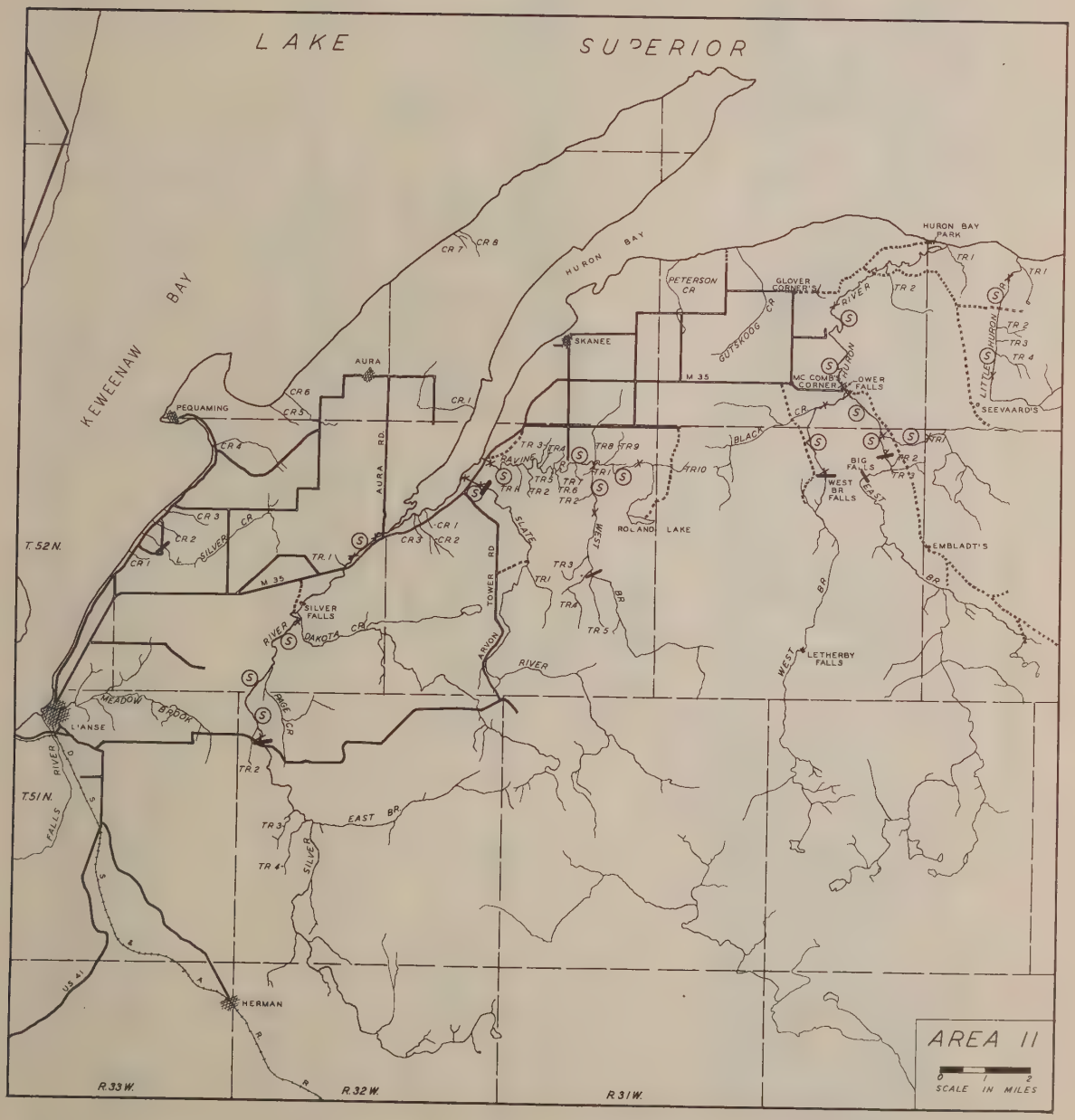

Figure 12.--Area 11.

Description of Area 11 (Fig. 12)

Embraces a section of the northern portion of Baraga County, Mich., and contains the Huron, Ravine, Slate, and Silver River watersheds, and several small coastal streams. All of these streams and their tributaries are potential sea lamprey producers, and in several of them rather questionable evidence of utilization was observed. Electrical control devices are recommended for the Huron, Slate, and Silver Rivers, and a mechanical structure for the Ravine. The streams of the area are brown in color. Gradients range from slight to steep, and surface velocities vary accordingly. Hard-bottom components of frequently inferior character (as spawning material) are common. Glaciated rocky terrain typifies much of the area, particularly in the east, but old lake sands and wet lowlands are more common to the west and along the Superior shore. Mixed growth composed of dominant hardwoods and some scrub popple forms the forest cover.

Table 12.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 12 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperatures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Kelsey Creek	Baraga, 52-33-27	10.25	8.0	0.25	Slight	1.0	56	9/6/50	Small	Spawning sites, obstacles, velocity	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

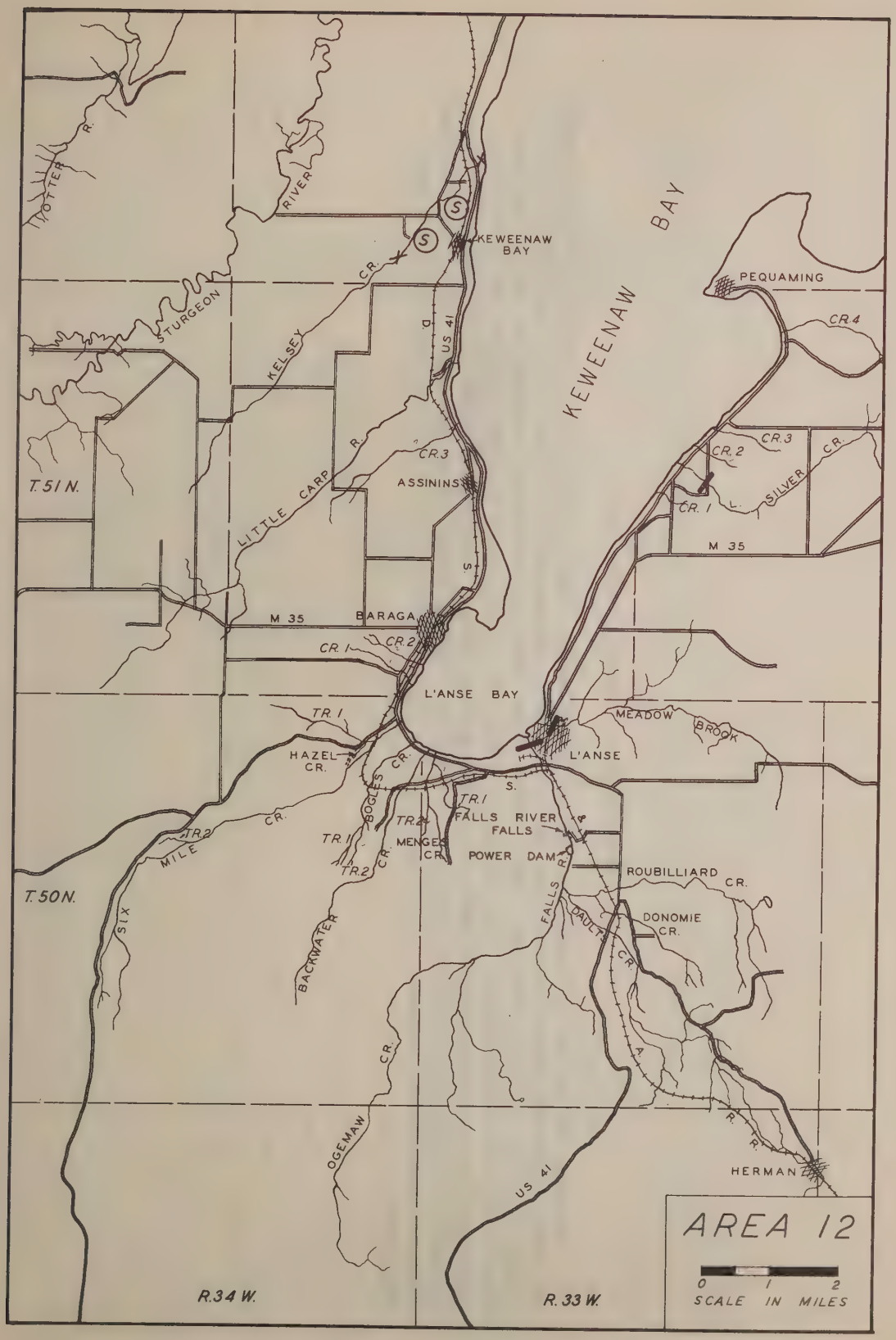

Figure 13.--Area 12.

Description of Area 12 (Fig. 13)

Embraces a portion of north and northwestern Baraga County, Mich., and contains the watersheds of the Falls and Little Carp Rivers, Little Silver, Backwater, Six Mile, and Kelsey Creeks, and a number of small coastal streams. Only Kelsey Creek has a productive potential; a mechanical control device is recommended. This stream is brown in color, has a slight gradient and low water velocity, and contains only a trace of spawning materials. The area is made up of level or slightly rolling, wet sand plain on the old glacial lake shores. Drainages are poorly defined, and bogs and swamps are common. Soils are light; alder-popple scrub and bog conifers characterize the area.

Table 13.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 13 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperatures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Sturgeon River	Houghton, 54-33-33	80.0	76.0	2.6	Slight-moderate	Sluggish-1.5	60-62	8/29	None	Spawning materials, level fluc., obstacles	Electrical
W. Br. Sturgeon River	Baraga, 51-34-16	26.0	27.5	0.66	Slight-moderate	1.75- ?	58	9/10	Large	Level fluc., obstacles, temperature	Electrical
Otter River	Houghton, 52-34-14	32.0	35.0	0.75	Slight-steep	1.0 -2.25	52	9/14	Large	Obstacles, level fluc., temperature	5/
N. Br. Otter River	Houghton, 51-35-1	26.0	22.0	1.0	Slight-moderate	1.5-1.75	50-54	9/9	Large	Level fluc., obstacles, temperature	5/
Bear Creek	Houghton, 52-35-25	1.75	12.0	0.5	Slight	Sluggish-1.25	---	---	Small	Obstacles, velocity, spawning materials	5/
Sante River	Houghton, 53-34-32	8.0	14.5	0.5	Slight	0.75-1.5	---	---	Medium	Spawning sites, obstacles, temperature	5/
Thirteen Creek	Houghton, 53-35-35	1.0	10.0	0.5	Slight	Sluggish-1.0	---	---	Small	Spawning sites, velocity, obstacles, temperature	5/
Bruno Creek	Houghton, 51-35-16	2.25	15.0	0.5	Moderate-steep	1.5-1.75	---	---	Small	Obstacles, temperature	5/
Lake Fifteen Cr.	Houghton, 51-35-19	0.5	6.0	0.5	Moderate-steep	1.75	---	---	Small	Spawning sites, temperature	5/
Pike River	Houghton, 53-33-5	8.0	18.0	1.0	Slight-moderate	1.0-1.5	52-54	9/3	Medium	Level fluc., velocity, temperature	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

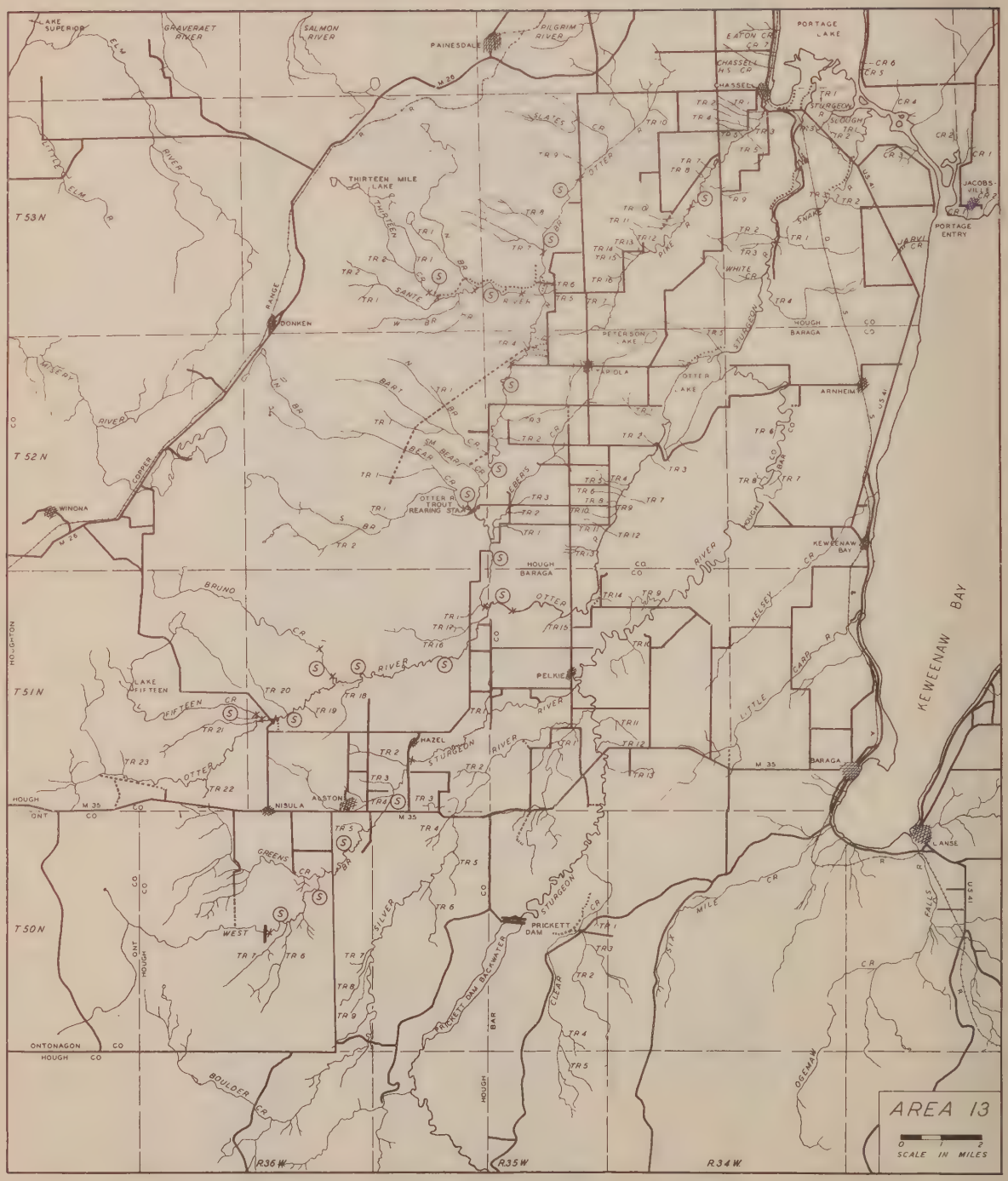

Figure 14.--Area 13.

Description of Area 13 (Fig. 14)

Embraces central Houghton County and portions of western Baraga and eastern Ontonagon Counties, Michigan, and contains the Sturgeon, Snake, and Pike River watersheds, and several small coastal streams. The tremendous Sturgeon system and the Pike watershed both contain abundant spawning facilities. An electrical device is recommended for the Sturgeon; a mechanical structure is suitable for the Pike. The streams of the area are generally brown in color and gradients are slight to steep. Hard-bottom materials are common, but soft components also occur frequently. Much of the area lies in the old lake clays region; the topography varies from wet bottoms to rolling hills. Forest and agricultural lands occur equally.

Table 14.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 14 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperatures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Pilgrim River	Houghton, 54-33-5	15.25	21.5	0.66	Slight-moderate	1.25-1.5	45-55	8/27-9/4	Large	Temperature, obstacles, level fluctuations	Mechanical weir & trap
Trap Rock River	Houghton, 55-32-5	12.0	27.5	1.25	Moderate	1.0-1.5	56-65	8/16 & 17	Medium	Level fluctuations, pollution, distance	Electrical
Hammell Creek	Houghton, 56-32-32	3.25	6.0	0.5	Slight-steep	0.75-2.0	63-64	8/17	Small	Spawning sites, velocity, pollution	5/
Sawmill Creek	Houghton, 55-32-5	6.0	6.0	0.5	Slight-steep	1.25-2.0	54-55	8/27	Medium	Obstacles, level fluc., temperature	Mechanical weir & trap
McCallum Creek	Houghton, 55-32-18	6.0	6.5	0.5	Slight-moderate	1.5-2.25	54	8/27	Medium	Obstacles, level fluc., temperature	Mechanical weir & trap
Lahti Creek	Houghton, 54-32-22	2.25	12.0	1.0	Slight	Sluggish-0.5	57	8/16	Small	Spawning sites, velocity	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

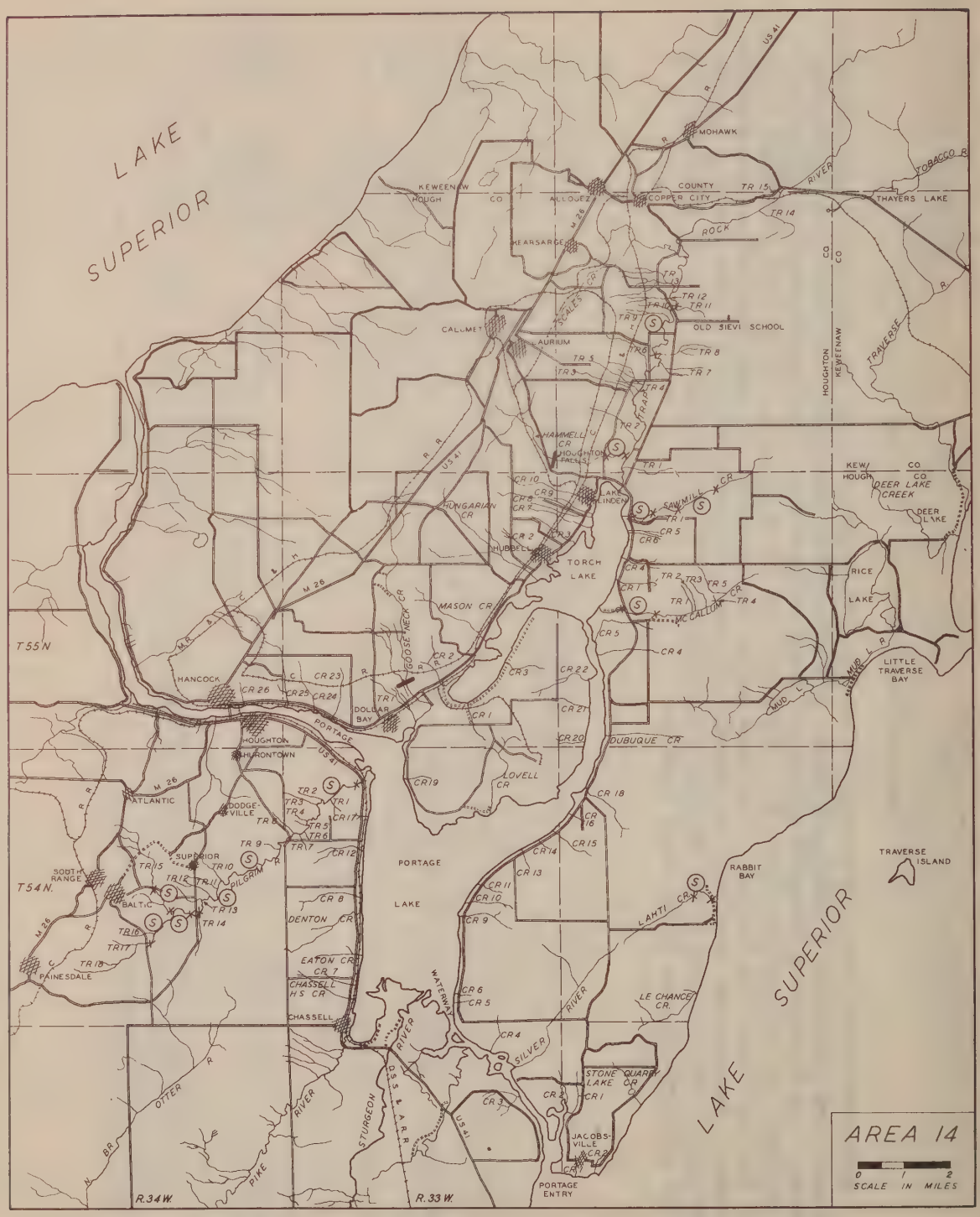

Figure 15.--Area 14.

Description of Area 14 (Fig. 15)

Embraces most of the northern half of Houghton and a small portion of Keweenaw County, Mich., and contains the watersheds of the Pilgrim and Trap Rock Rivers, Hammell, Lahti, Gooseneck, Sawmill, and McCallum Creeks, and a large number of small coastal streams tributary to either Lake Superior or the Portage Waterway. Appreciable productive potentials occur in all but Lahti and Gooseneck Creeks. Mechanical control devices are recommended for all the potential producers but the Trap Rock; an electrical device will be necessary in that stream. The streams of the area are generally brown in color and clear (except for some transient turbidity in the Trap Rock due to pollution). Gradients range from slight to steep. Hard-bottom materials are plentiful. The topography is broken, and drainages are well defined. Agricultural lands predominate in the valleys, but much forested upland and timbered bog are present.

Table 15.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 15 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Tempera-tures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Traverse River	Houghton, 55-31-4	11.5	13.5	1.0	Slight	1.0-2.25	55-57	8/14,16/50	Medium	Spawning sites, fluctuations, obstacles	Electrical
Tobacco River	Keweenaw, 56-30-20	22.0	13.5	1.0	Slight-moderate	0.5-3.5	66-68	8/10	Medium	Spawning sites, fluctuations, obstacles	Electrical
Big Betsy River	Keweenaw, 57-30-36	3.5	7.5	1.0	Slight	Sluggish-0.75	62-64	8/9	Small	Velocity, obstacles	Mechanical weir & trap
Little Betsy River	Keweenaw, 57-29-29	1.75	6.0	0.75	Slight-moderate	0.5-2.5	---	---	Small	Spawning sites, fluctuations, obstacles, temperature	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from t 'al length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place control device.

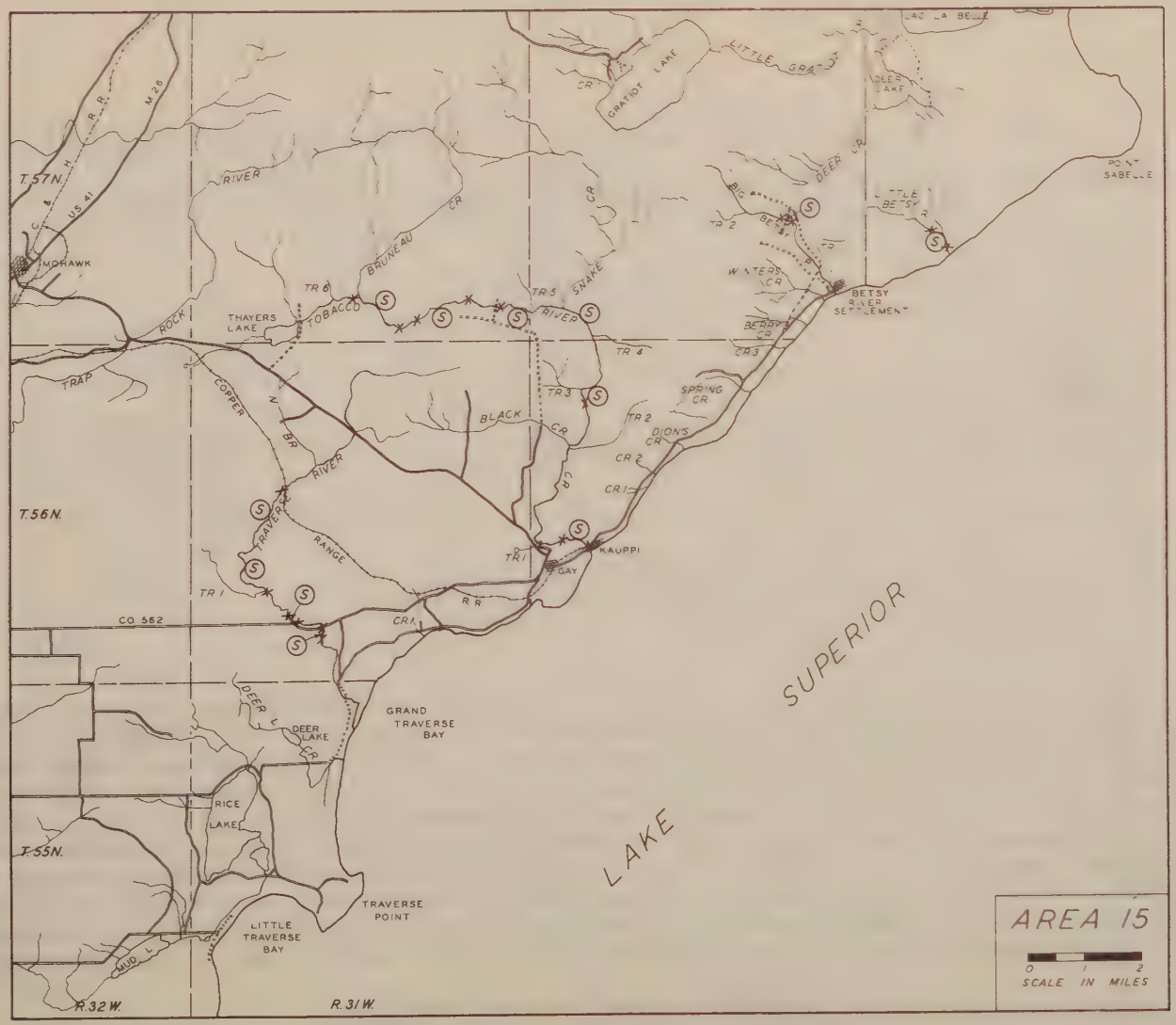

Figure 16.—Area 15.

Description of Area 15 (Fig. 16)

Embraces the southeastern portion of Keweenaw County, Mich., and contains the watersheds of the Traverse, Tobacco, Big Betsy, and Little Betsy Rivers, and several small coastal streams. All of the named streams are potential sea lamprey producers, but only the Traverse and Tobacco are significantly dangerous. A questionable record of five "probable" nests exists for the Traverse. Electrical control devices are recommended for both the Traverse and Tobacco Rivers; electrical devices will also be more suitable in the Betsy Rivers if power lines are made available. The streams in the area are generally brown in color and gradients range from slight to steep. Hard-bottom materials are abundant. The topography ranges from low, sandy plains and bogs in the lower watersheds to rugged, rocky, upland wilderness; glaciated soils and land features characterize the area. Ecological situations are equally varied and complex.

Table 16.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 16 (Survey made in 1950)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperatures in degrees F.	Date	Productive potential	Possible limiting factors	Type of control possible 4/
Little Gratiot River	Keweenaw, 58-29-31	8.5	14.0	1.75	Moderate	1.5-2.0	66-70	7/30	Large	Fluctuations, obstacles, isolation	Electrical
Sister Creek	Keweenaw, 57-30-4	5.0	3.0	0.5	Slight-steep	Sluggish-1.5	53	8/2	Small	Spawning sites, velocity, obstacles	5/
Nine Thirty Two Creek	Keweenaw, 57-30-8	1.5	3.0	0.5	Slight-steep	?-1.0	---	---	Small	Velocity, temperature	5/
Bear Creek	Keweenaw, 58-28-30	2.0	5.5	0.66	Moderate-steep	Sluggish-1.0	51-53	7/24 & 8/3	Small	Spawning sites, fluc., velocity, obstacles, temperature	Mechanical weir & trap
Boar Creek	Keweenaw, 58-28-25	2.0	4.0	0.25	Slight	0.5	60	7/27	Small	Spawning sites, velocity, obstacles	Mechanical weir & trap
Union Creek	Keweenaw, 58-27-21	4.5	5.0	0.5	Slight-moderate	0.5-1.5	62	7/27	Small	Obstacles	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

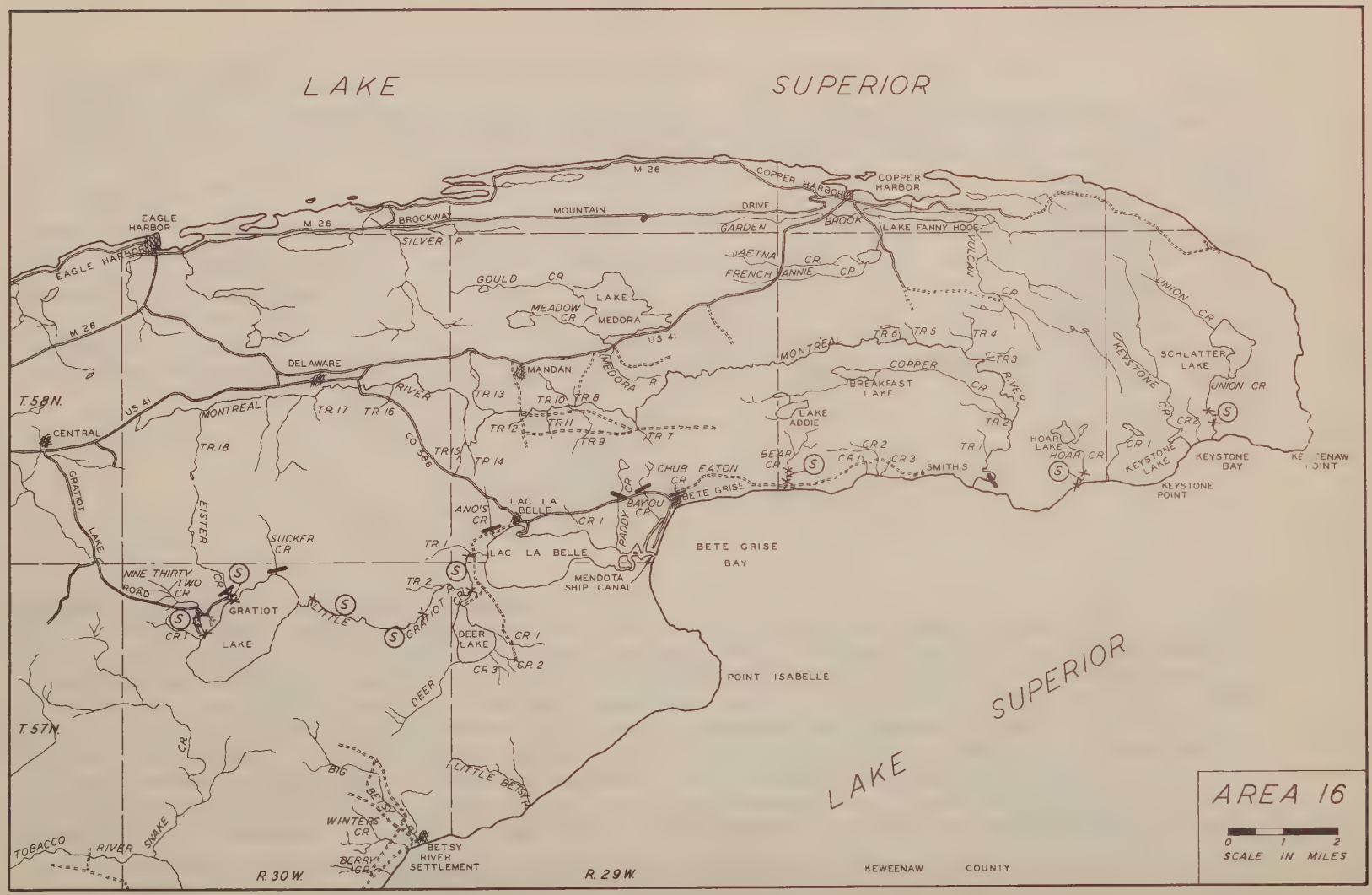

Figure 17.—Area 16.

Description of Area 16 (Fig. 17)

Embraces most of the southeastern portion of Keweenaw County, Mich., and contains the watersheds of the Little Gratiot River-Mendota system, the Montreal River, Bear, Hoar, and Union Creeks, and a number of small coastal streams; all but the Montreal have a productive potential; only the Little Gratiot is considered dangerous. An electrical installation is recommended for the Little Gratiot; mechanical devices will be suitable in the other streams. The streams in the area are uniformly brown in color and gradients range from slight to steep. Hard-bottom types are abundant only in the Little Gratiot. Characteristically the area is rugged, rocky, mountainous upland, but a narrow band of low, swampy, sand plain borders the lakeshore; soils are generally light and thin. Coniferous stands in the lowlands and mixed hardwoods on the slopes form the forest cover.

Table 17.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 17
(Survey made in 1951)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperature in degrees F.	Date	Number of potential nest sites observed 3/	Productive potential	Possible limiting factors	Type of control possible 4/
Lake Fanny Hooe Creek	Keweenaw, 59-28-33	0.5	25.0	1.0	Moderate	1.5	62	7/24	None	0	---	Barrier dam
Mud Lake Creek	Keweenaw, 59-28-34	0.5	15.0	0.75	Slight	Sluggish	---	---	12	Medium	Temperature	5/
Vulcan Creek	Keweenaw, 59-28-34	9.0	8.0	0.25	Moderate	1.0	61	7/23	25	Medium	Irregular bottom	5/
Garden Brook	Keweenaw, 59-28-32	5.5	8.0	0.2	Slight-moderate	0-1.0	---	---	40	Medium	Temperature, velocity	5/
Glazon Creek	Keweenaw, 59-29-31	0.75	3.0	0.2	Slight	0-1.0	---	---	3	Small	Temperature	Mechanical weir & trap
Silver River	Keweenaw, 59-30-35	7.0	20.0	1.0	Slight-steep	Sluggish-1.0	57	7/24	100	Large	Temperature	Barrier dam
Little Silver River	Keweenaw, 59-30-35	1.0	3.0	0.2	Slight-steep	0.5-1.0	58	7/24	---	Medium	Temperature, irregular bottom	5/
Cedar Creek	Keweenaw, 58-30-5	5.0	6.0	0.5	Slight-steep	0.5	56	7/24	40	Medium	Temperature, velocity, irregular bottom	Electrical
Elizo Lake Creek	Keweenaw, 58-30-6	1.0	15.0	0.5	Slight-steep	0.5	64	7/24	80	Large	Velocity	Mechanical weir & trap

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

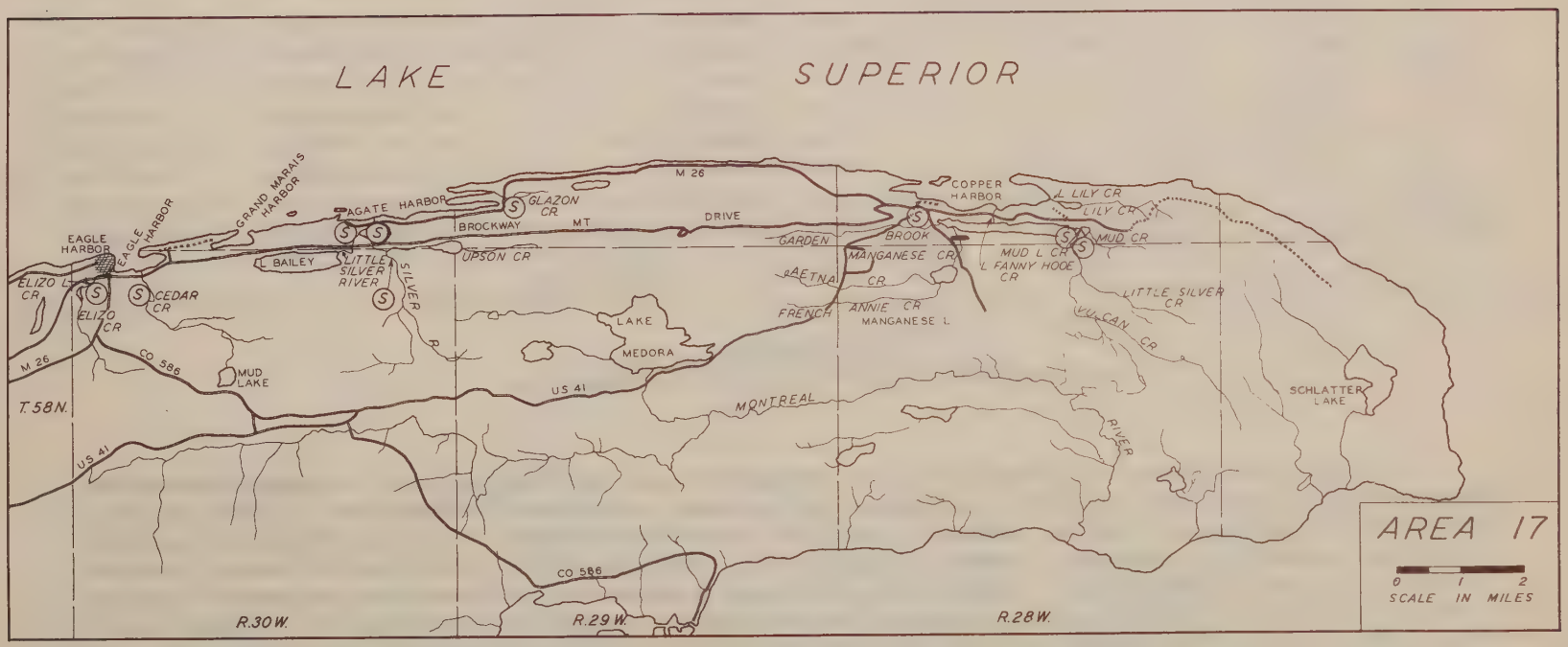

Figure 18.—Area 17.

Description of Area 17 (Fig. 18)

Embraces the northeast portion of Keweenaw County, Mich., and contains six small river systems. Some type of control may be required in five of them. The Silver River, Elizo Creek, and the Lake Fanny Hooe Creek systems appear to be capable of producing large numbers of sea lampreys; Glazon and Cedar Creeks have facilities for fewer nests. The Silver River and Lake Fanny Hooe Creek systems may be controlled by concrete barrier dams which can be constructed on bedrock substrata. Sites for mechanical weirs are present close to the mouths of Elizo Lake and Glazon Creeks, but an electrical control device will probably be necessary in Cedar Creek because of the low banks. All of the control sites are readily accessible. Stream gradients are generally steep, and water velocities are high in some stream sections. The stream bottoms are largely hard and irregular. Low water temperatures and sudden freshets may limit the amount of spawning and the freshets may interfere with control operations.

Table 18.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 18
(Survey made in 1951)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperature in degrees F.	Date	Number of potential nest sites observed 3/	Productive potential	Possible limiting factors	Type of control possible 4/
Garden City Brook	Keweenaw, 58-31-19	4.0	10.0	0.3	Moderate-steep	1.0	63	7/25	40	Medium	None	Mechanical weir & trap Electrical
Morrison Creek	Keweenaw, 58-32-26	7.0	20.0	0.2	Slight-steep	Sluggish	61	7/27	50	Medium	None	
Gratiot River	Keweenaw, 57-33-11	25.0	40.0	0.5	Slight-steep	0.5	60	7/28	200 +	Large	None	Electrical
Hill Creek	Keweenaw, 57-33-14	18.0	15.0	0.5	Slight-moderate	1.0	56	7/31	100 +	Large	Temperature	Electrical
Black Creek	Keweenaw, 57-33-14	14.0	10.0	0.75	Slight-steep	0.0-Sluggish	62	7/31	25	Medium	Drying	5/

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

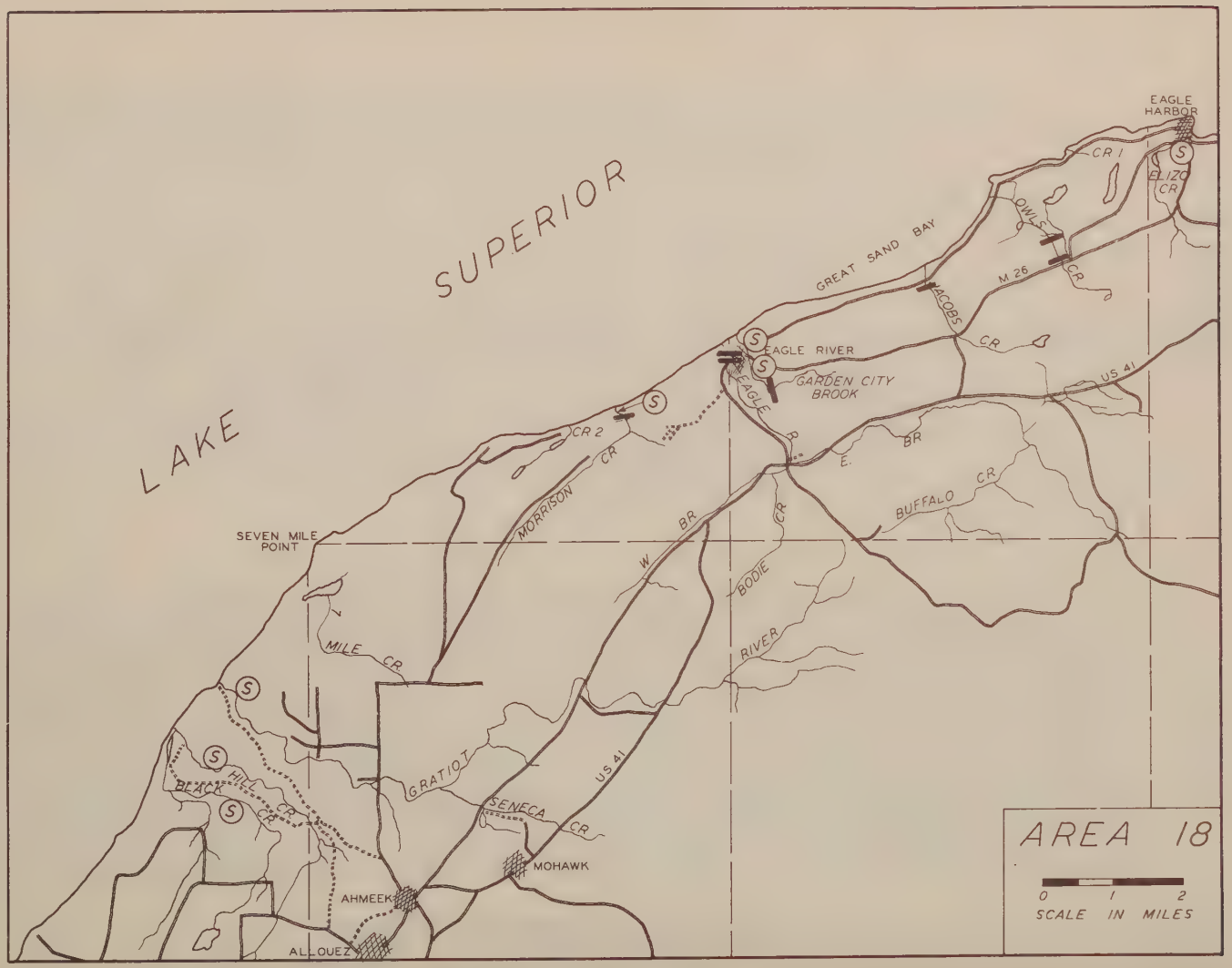

Figure 19.—Area 18.

Description of Area 18 (Fig. 19)

Embraces the northwest portion of Keweenaw County, Mich., and contains nine small river systems. Abundant spawning facilities are available in the Gratiot River and in the Hill Creek system; sites for fewer nests (40-50) are present in both Garden City Brook and Morrison Creek. A mechanical weir can be constructed close to the mouth of Garden City Brook. Electrical devices will be more practical in the other streams; good sites for mechanical weirs are lacking. Morrison Creek is relatively inaccessible. The stream gradients are generally steep, and velocities are high during the spring. The surrounding country is sandy and rugged. Hardwoods are predominant.

Table 19.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 19
(Survey made in 1951)

Name of stream [1]	County, township line, range, and section no. at mouth	Length of stream in miles [2]	Average width of stream in ft. [3]	Average depth of stream in ft. [3]	Range in gradient [3]	Range in velocity in ft./sec. [3]	Temperature in degrees F.	Date	Number of potential nest sites observed [3]	Productive potential	Possible limiting factors	Type of control possible [4]
Brewery Creek	Houghton, 56-33-5	7.0	3.0	1.5	Moderate	0.5	62	7/31	4	Small	Small size, irregular bottom	Mechanical weir & trap
Gardener's Creek	Houghton, 56-33-6	3.5	4.0	0.25	Slight-steep	1.0-3.0	63	7/31	4	Small	Irregular bottom	Mechanical weir & trap
Creek # 1	Houghton, 56-33-7	1.0	6.0	0.25	Moderate-steep	1.5	56	7/31	30	Medium	Temperature, velocity	Mechanical weir & trap
Creek # 2	Houghton, 56-33-7	3.0	4.0	0.25	Moderate-steep	1.5	67	7/31	30	Medium	Velocity	Mechanical weir & trap
Creek # 3	Houghton, 56-33-7	2.0	2.0	0.25	Moderate-steep	1.5	60	7/31	6	Medium	Velocity	Mechanical weir & trap
McGunn's Creek	Houghton, 56-34-12	6.5	20.0	0.3	Moderate-steep	2.0	66	7/31	12	Medium	Irregular bottom	Mechanical weir & trap
Smith Creek	Houghton, 56-34-13	5.0	3.0	0.3	Steep	1.0-2.0	66	8/1	3	Small	Irregular bottom	Mechanical weir & trap
Creek # 5	Houghton, 56-34-13	2.5	3.0	0.1	Moderate-steep	0.0-sluggish	61	7/31	4	Small	Irregular bottom, small size	Mechanical weir & trap
Bear Creek	Houghton, 56-34-14	6.0	17.0	2.0	Slight-moderate	1.0	56	8/1	25	Medium	Temperature	Mechanical weir & trap
Boston Creek	Houghton, 56-34-33	8.0	25.0	0.5	Slight-steep	1.5	57	8/1	100 +	Large	Temperature	Electrical
Lily Creek	Houghton, 56-34-34	10.0	30.0	0.5	Slight-steep	1.0	61	8/1	200 +	Large	None	5/
Creek # 1	Houghton, 55-34-4	2.5	3.0	0.3	Steep	1.0 +	64	8/1	4	Small	Small size, velocity, irregular bottom	Mechanical weir & trap
Creek # 2	Houghton, 55-34-9	3.0	5.0	0.2	Steep	1.0	56	8/1	8	Medium	Temperature, irregular bottom	Mechanical weir & trap
Creek # 4	Houghton, 55-34-16	1.0	8.0	0.1	Steep	0.75	55	8/1	3	Small	Temperature, velocity, irregular bottom	Mechanical weir & trap
Swede Town Creek	Houghton, 55-34-28	6.0	18.0	0.25	Moderate-steep	1.0 +	61	8/1	65	Medium	Temperature, velocity, irregular bottom	Mechanical weir & trap
Creek # 1	Houghton, 55-34-35	5.0	20.0	0.1	Slight-steep	0.75	70	8/2	4	Small	Irregular bottom, drying	Mechanical weir & trap
Coles Creek	Houghton, 55-34-28	8.0	25.0	0.5	Steep	3.0	54	8/2	4	Small	Temperature, velocity, irregular bottom	Electrical
Schlotz Creek	Houghton, 55-34-8	8.0	15.0	0.5	Slight-moderate	1.0 +	56	8/1	100 +	Large	Temperature	Mechanical weir & trap
Salmon Trout River	Houghton, 55-35-20	22.0	40.0	0.25	Moderate	Sluggish-1.0	62	8/3	12	Medium	None	Electrical
Graveraet River	Houghton, 55-36-35	17.0	25.0	1.0	Slight-steep	1.5	54	8/6	100 +	Large	None	Barrier dam
Elm River	Houghton, 54-36-30	26.0	30.0	0.4	Moderate-steep	1.5-2.0	59	8/7	50	Medium	Temperature, velocity, irregular bottom	Electrical
South Branch Elm R.	Houghton, 54-36-30	8.0	20.0	0.8	Slight-steep	1.0 +	59	8/7	100 +	Large	Temperature, velocity	5/
Little Elm River	Houghton, 54-36-31	14.0	35.0	1.0	Slight-steep	0.0-1.5	60	8/8	50	Medium	None	Electrical

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2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

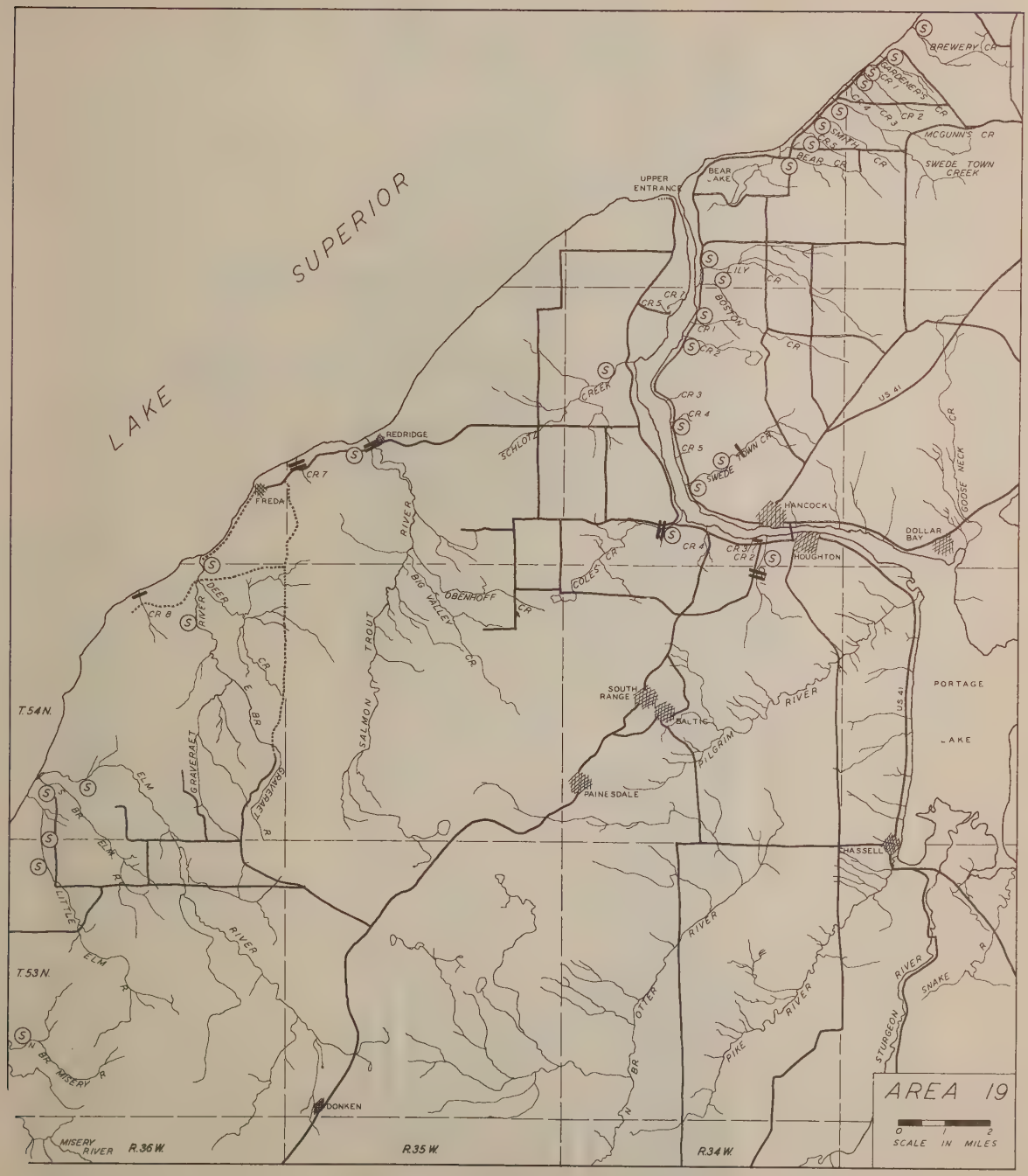

Figure 20.--Area 19.

Description of Area 19 (Fig. 20)

Embraces the entire northern coastline of Houghton County, Mich., and the northern portion of the Portage Waterway. Spawning facilities are available in 21 river systems, 8 of which flow into the Portage Waterway. Abundant facilities are present in four watersheds: Boston and Schlotz Creeks, tributary to the canal, and the Graveraet and Elm Rivers in the western portion of the area. Ten other watersheds each offer facilities for from 6 to 65 nests. Sites for less than 5 nests are present in each of the remaining streams listed (table 19). Sites for mechanical weirs are present near the mouths of 15 streams. Electrical control devices are recommended for the Salmon Trout, Elm, and Little Elm Rivers, which are too large for practical mechanical structures, and for Boston and Coles Creeks in which sites for mechanical weirs are lacking. A concrete barrier dam is recommended for the Graveraet River. The Graveraet and Elm Rivers are relatively inaccessible. Stream gradients are generally steep, and velocities are high. Low water temperatures and freshets may inhibit spawning. The large water volumes present in the spring and during periods of heavy rain may interfere with control operations. The country east of the Portage Waterway is generally sandy while morainic formations and lake clays are predominant to the west. The entire area is rugged. The forest climax type is largely hardwood.

Table 20.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 20
(Survey made in 1951)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperature in degrees F.	Date	Number of potential nest sites observed 3/	Productive potential	Possible limiting factors	Type of control possible 4/
Misery River	Ontonagon, 53-37-10	30.0	45.0	2.0	Slight-moderate	0.0-2.0	54	8/11	80	Large	Temperature	Electrical
East Sleeping River	Ontonagon, 53-38-13	30.0	60.0	0.5	Slight-steep	Sluggish-1.0	60	8/25	200 +	Large	None	Electrical
West Sleeping River	Ontonagon, 53-38-13	11.0	10.0	0.3	Slight-moderate	Sluggish-1.5	59	8/24	100 +	Large	Temperature	Electrical
Firesteele River	Ontonagon, 52-39-1	75.0	40.0	1.0	Slight-steep	Sluggish-2.0	72	8/27	1000 +	Large	None	Electrical
Flintsteele River	Ontonagon, 52-39-2	33.0	100.0	6.0	Slight	Sluggish-0.75	73	8/27	100 +	Large	None	Electrical
Bear Creek	Ontonagon, 52-39-15	16.0	20.0	0.5	Slight-moderate	Sluggish-1.0	---	---	4	Small	Temperature	Mechanical weir & trap
Ontonagon River	Ontonagon, 52-40-25	100 +	100.0	2.0	Slight-steep	Sluggish-5.0	59	8/23	200 +	Large	None	Electrical
First Creek	Ontonagon, 52-40-34	14.0	10.0	0.5	Slight-moderate	Sluggish	60	8/22	4	Small	Spawning materials	Mechanical weir & trap
Second Creek	Ontonagon, 52-40-34	14.0	12.0	0.5	Slight	Sluggish-1.0	58	8/25	4	Small	Temperature, spawning materials	Mechanical weir & trap
Potato River	Ontonagon, 52-40-33	30.0	35.0	2.0	Slight-moderate	Sluggish-1.0	58	8/22	100 +	Large	Temperature	Electrical
Floodwood River	Ontonagon, 51-40-4	17.0	20.0	0.5	Slight-moderate	Sluggish	58	8/25	75	Large	Temperature, velocity	Electrical
Cranberry River	Ontonagon, 51-40-6	25.0	40.0	0.6	Slight-moderate	Sluggish	64	8/27	100 +	Large	None	Electrical
Little Cranberry R.	Ontonagon, 51-40-6	16.0	30.0	1.0	Moderate	Sluggish	63	8/29	100 +	Large	None	Electrical

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices probably can be installed in all streams for which mechanical weirs and traps have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

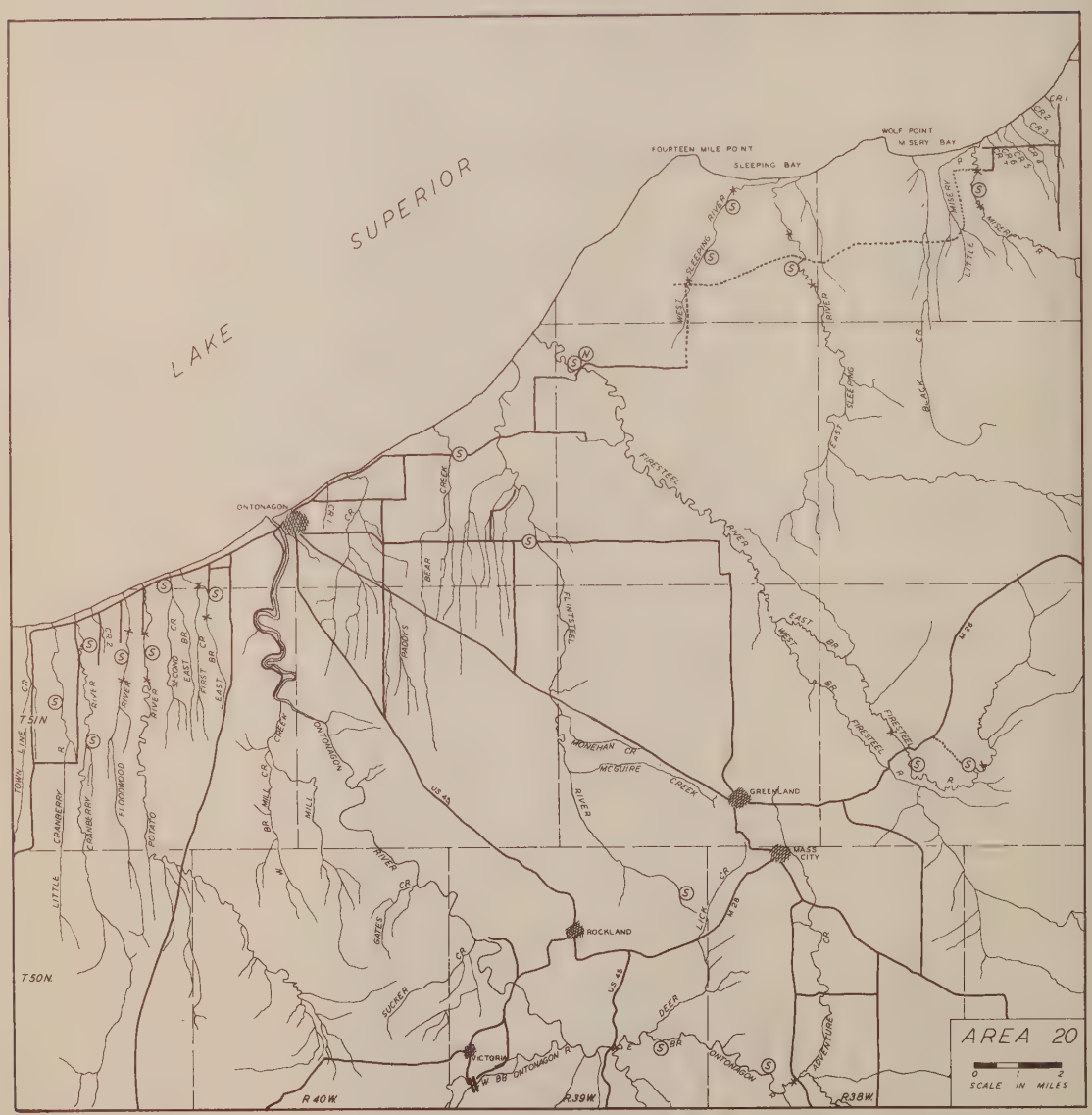

Figure 21.—Area 20.

Description of Area 20 (Fig. 21)

Embraces the northeast portion of Ontonagon County, Mich., and contains at least 13 streams in which sea lampreys may spawn. The status of Paddys Creek and Creek No. 1 just east of Ontonagon, and of Black Creek just east of Wolf Point is unknown at present. Abundant spawning facilities are present in all but three of the streams. Sites for mechanical weirs are present in these three, and the streams themselves are small enough for practical operation of such devices. The 10 streams capable of producing great numbers of sea lampreys are all large, and electrical control devices are recommended for them. Control may be especially difficult in the Ontonagon, Flintsteel, and Firesteel Rivers because of their large size. One lamprey nest was observed in the Firesteel River in 1951. Stream gradients are generally steep, and velocities above the area of "lake level effect" are high. Most of the streams are exceedingly turbid during periods of heavy rain, and changes in water levels are rapid. Low water temperatures and high velocities may limit spawning in some streams. Control operations will be hampered by the inaccessibility of the three or four suitable streams east of Fourteen Mile Point. The entire area is rugged, and lake clay soils are predominant. The forest climax type is largely hemlock-hardwood. Much of the area has been logged recently and is covered with impenetrable slash and second growth.

Table 21.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 21 (Survey made in 1951)

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperature in degrees F.	Date	Number of potential nest sites observed 3/	Productive potential	Possible limiting factors	Type of control possible 4/
Town Line Creek	Ontonagon, 51-41-1	19.0	25.0	0.6	Slight-moderate	0.75	54	9/5	100 +	Large	Temperature	Electrical
Halfway River	Ontonagon, 51-41-1	34.0	30.0	2.0	Moderate-steep	1.5	59	9/6	100 +	Large	Temperature	Electrical
Duck Creek	Ontonagon, 51-41-11	31.0	30.0	0.5	Slight-moderate	1.5	54	9/5	80	Large	Temperature	Electrical
Pine River	Ontonagon, 51-41-3	22.0	20.0	1.0	Slight-moderate	Sluggish-1.0	55	9/5	100 +	Large	Temperature	Electrical
Stony Creek	Ontonagon, 51-41-3	14.0	14.0	0.5	Slight-moderate	Sluggish-1.0	54	9/4	40	Medium	Temperature, irregular bottom	Mechanical weir & trap
Mineral River	Ontonagon, 51-41-7	24.0	50.0	1.0	Slight-moderate	1.0-2.0	61	9/4	250 +	Large	Temperature	Electrical
Iron River	Ontonagon, 51-42-12	80.0	200.0	---	Moderate-steep	1.0-5.0	---	---	100 +	Unknown	---	Electrical
Little Iron River	Ontonagon, 51-42-11	25.0	35.0	0.75	Steep	1.5	52	9/4	100 +	Large	Temperature	Electrical
Union River	Ontonagon, 51-42-15	14.0	40.0	1.0	Slight-steep	Sluggish-2.0	51	9/3	200 +	Large	Temperature	Electrical
Carp River	Ontonagon, 51-44-33	30.0	35.0	0.8	Moderate-steep	0.5-2.0	53	9/9	35	Medium	Temperature, irregular bottom	Barrier dam

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2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

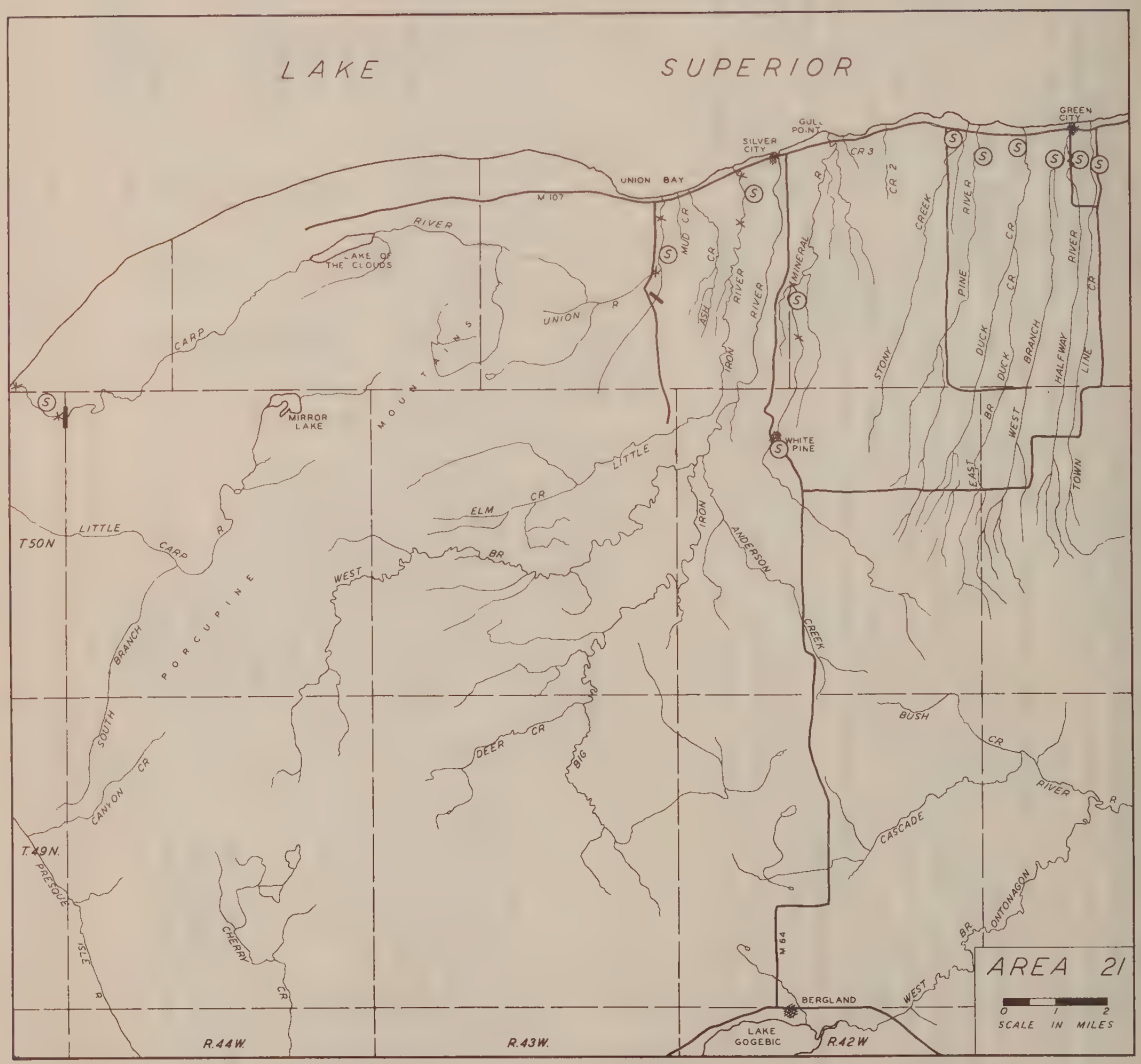

Figure 22.—Area 21.

Description of Area 21 (Fig. 22)

Embraces the northwest portion of Ontonagon County, Mich., and contains at least 9 streams with spawning facilities for sea lampreys. At present, the status of the Iron River and Ash and Mud Creeks is unknown. The shoreline from the Carp River east to Union Bay has not been surveyed; several small streams may be present in this area. Seven streams have a large productive potential while two, Stony Creek and the Carp River, have facilities for fewer nests (30 each). A site for a mechanical weir is present just above the mouth of Stony Creek. The remaining streams (excepting the Carp River in which a barrier can be placed) are too large for control by mechanical means, and electrical devices are recommended. The Carp River is relatively inaccessible. Stream gradients are generally steep above the areas of "lake level effect," and velocities are high. The large water volumes and resulting heavy turbidity may interfere seriously with control operations in the spring and during periods of heavy rain. The surrounding country is rugged. Lake clay soils and a forest climax type of hemlock-hardwood are predominant.

Table 22.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 22
(Survey made in 1951)

Name of stream [1]	County, township line, range, and section no. at mouth	Length of stream in miles [2]	Average width of stream in ft. [3]	Average depth of stream in ft. [3]	Range in gradient [3]	Range in velocity in ft./sec. [3]	Temperature in degrees F.	Date	Number of potential nest sites observed [3]	Productive potential	Possible limiting factors	Type of control possible [4]
Creek # 2	Gogebic, 50-45-2	1.0	10.0	0.2	Slight-moderate	1.0	56	9/9	50	Medium	Temperature	Barrier dam
Creek # 3	Gogebic, 50-45-2	1.0	6.0	0.2	Slight-moderate	1.0	56	9/9	50	Medium	Temperature	Barrier dam
Little Carp River	Gogebic, 50-45-2	35.0	35.0	0.8	Moderate-steep	0.5-2.0	56	9/9	100 +	Large	Temperature	Barrier dam
Creek # 4	Gogebic, 50-45-2	1.0	2.0	0.1	Steep	0.75	56	9/9	4	Small	Temperature, size	Barrier dam
Creek # 5	Gogebic, 50-45-2	1.0	10.0	0.1	Steep	0.75	55	9/9	25	Medium	Temperature, irregular bottom	Barrier dam
Pinkerton Creek	Gogebic, 50-45-10	8.0	30.0	0.5	Steep	1.5	56	9/9	80	Large	Temperature	Barrier dam
Kenabeek Creek	Gogebic, 50-45-16	5.0	15.0	0.25	Moderate-steep	0.5-1.0	56	9/10	15	Medium	Temperature, velocity, irregular bottom	Barrier dam
Creek # 7	Gogebic, 50-45-16	3.0	5.0	0.25	Slight	Sluggish-0.5	56	9/10	25	Medium	Temperature	Electrical
Creek # 8	Gogebic, 50-45-16	2.0	12.0	0.25	Moderate	1.0	58	9/10	40	Medium	Temperature	Electrical
Tiebel Creek	Gogebic, 50-45-16	12.0	25.0	0.5	Moderate	1.0 +	55	9/10	100 +	Large	Temperature	Electrical
Speaker Creek	Gogebic, 50-45-16	8.0	25.0	0.5	Moderate	1.0 +	55	9/10	100 +	Large	Temperature	Electrical
Cardinal Creek	Gogebic, 50-45-20	3.0	20.0	0.25	Steep	0.5-1.0	53	9/8	12	Medium	Temperature, freshets, irregular bottom	Barrier dam
Creek # 1	Gogebic, 50-45-20	1.0	6.0	0.25	Steep	0.5-1.0	53	9/8	12	Medium	Temperature, freshets, irregular bottom	Barrier dam
Big Presque Isle R.	Gogebic, 50-45-19	50 +	75.0	2.0	Moderate-steep	2.0-4.0	59	9/13	10	Medium	Temperature, velocity	Electrical
Camp B Creek	Gogebic, 50-46-25	5.0	20.0	0.6	Steep	2.0	60	9/13	50	Medium	Velocity	Electrical
Creek # 1	Gogebic, 50-46-36	1.0	6.0	0.5	Moderate-steep	2.0 +	58	9/13	30	Medium	Temperature, velocity	Barrier dam
Creek # 2	Gogebic, 50-46-36	1.0	3.0	0.25	Moderate-steep	1.0	58	9/13	30	Medium	Temperature	Barrier dam
Namebinag Creek	Gogebic, 50-46-35	5.0	8.0	0.5	Moderate-steep	2.0	58	9/13	80	Large	Temperature	Barrier dam
Gijik Creek	Gogebic, 49-46-2	4.0	10.0	0.3	Steep	1.0-2.0	56	9/14	50	Medium	Temperature	Electrical
Creek # 3	Gogebic, 49-46-2	2.0	3.0	0.25	Moderate-steep	1.0	56	9/14	25	Medium	Temperature	Barrier dam
Creek # 4	Gogebic, 49-46-2	2.0	5.0	0.2	Moderate-steep	1.0	56	9/14	40	Medium	Temperature	Barrier dam
Tanager Creek	Gogebic, 49-46-2	4.0	6.0	0.3	Steep	0.5-1.0	55	9/16	35	Medium	Temperature	Barrier dam
Bobolink Creek	Gogebic, 49-46-2	4.0	6.0	0.3	Moderate-steep	0.5-1.0	53	9/15	50	Medium	Temperature	Barrier dam
Chickadee Creek	Gogebic, 49-46-3	4.0	3.0	0.25	Moderate	1.0	53	9/15	15	Medium	Temperature	Barrier dam
Black River	Gogebic, 49-46-3	50 +	125.0	6.0	Moderate	2.0-3.0	57	9/17	15	Medium	Temperature	Electrical
Paloface Creek	Gogebic, 49-46-9	2.0	6.0	0.3	Steep	1.0	51	9/17	25	Medium	Temperature	Barrier dam

Table 22, continued

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in Gradient 3/	Range in velocity in ft./sec. 3/	Temperature in degrees F.	Date	Number of potential nest sites observed 3/	Productive potential	Possible limiting factors	Type of control possible 4/
Creek # 18	Gogebic, 49-47-20	1.0-2.0	6.0	0.25	Steep	1.0	54	9/20	25	Medium	Temperature, freshets	Barrier dam
Creek # 17	Gogebic, 49-47-20	1.0-2.0	4.0	0.2	Moderate	1.0	46	9/25	10	Medium	Temperature, freshets	Barrier dam
Creek # 16	Gogebic, 49-47-20	1.0-2.0	8.0	0.25	Moderate-steep	1.0	46	9/25	25	Medium	Temperature, freshets	Barrier dam
Creek # 15	Gogebic, 49-47-20	1.0	6.0	0.25	Steep	1.0	48	9/25	50	Medium	Temperature, freshets	Barrier dam
Creek # 14	Gogebic, 49-47-20	1.0-2.0	2.0	0.1	Moderate	1.0	48	9/25	1	Small	Temperature, small size, freshets	Barrier dam
Creek # 13	Gogebic, 49-47-19	1.5	3.0	0.1	Moderate	1.0	46	9/25	4	Small	Temperature, freshets	Barrier dam
Creek # 12	Gogebic, 49-47-19	1.0-2.0	6.0	0.25	Moderate	1.0	48	9/25	80	Large	Temperature, freshets	Barrier dam
Creek # 11	Gogebic, 49-47-19	1.0-2.0	2.0	0.1	Steep	1.0	48	9/25	4	Small	Temperature, small size, freshets	Barrier dam
Creek # 10	Gogebic, 49-47-19	1.0	6.0	0.25	Moderate	1.0	48	9/25	12	Medium	Temperature, freshets	Barrier dam
Creek # 9	Gogebic, 49-47-19	1.0-2.0	4.0	0.25	Moderate	1.0	48	9/25	12	Medium	Temperature, freshets	Barrier dam
Creek # 8	Gogebic, 49-48-25	1.0-2.0	10.0	0.25	Moderate-steep	1.0	49	9/26	12	Medium	Temperature, freshets	Barrier dam
Montana Creek	Gogebic, 49-48-25	3.0	12.0	0.3	Moderate	1.0	48	9/26	80	Large	Temperature, freshets	Barrier dam
Killdeer Creek	Gogebic, 49-48-26	2.5	6.0	0.3	Moderate-steep	1.5	48	9/26	5	Small	Temperature, freshets	Barrier dam
Scalp Creek	Gogebic, 49-48-27	3.0	12.0	0.5	Moderate-steep	1.0	45	9/27	7	Medium	Temperature, freshets	Barrier dam
Creek # 4	Gogebic, 49-48-27	1.0-2.0	4.0	0.3	Moderate-steep	1.0	45	9/27	1	Small	Temperature, freshets	Barrier dam
Little Speckled Creek	Gogebic, 49-48-34	4.0	10.0	0.3	Moderate-steep	1.0	45	9/27	12	Medium	Temperature, freshets	Barrier dam
Creek # 3	Gogebic, 49-48-33	1.0-2.0	2.0	0.25	Moderate	0.75-1.0	45	9/26	12	Medium	Temperature, small size, freshets	Barrier dam
Creek # 2	Gogebic, 49-48-33	1.0-2.0	6.0	0.25	Moderate	0.75-1.0	45	9/26	50	Medium	Temperature, freshets	Barrier dam
Creek # 1	Gogebic, 49-48-33	1.0-2.0	6.0	0.2	Moderate	0.75-1.0	51	9/19	7	Medium	Temperature, freshets	Electrical
Ikwesens Creek	Gogebic, 49-48-32	3.0	6.0	0.25	Moderate	0.75-1.0	52	9/19	10	Medium	Temperature	Electrical
Creek # 2	Gogebic, 49-48-32	1.0-2.0	10.0	0.3	Moderate	0.75-1.0	53	9/19	6	Medium	Temperature	Electrical
Ohman Creek	Gogebic, 49-48-31	6.0	8.0	0.3	Moderate-steep	1.0	54	9/25	25	Medium	Temperature	Barrier dam
Flink Creek	Gogebic, 48-49-11	3.0	8.0	0.3	Moderate-steep	1.0	56	9/25	25	Medium	Temperature	Barrier dam
Treasure Creek	Gogebic, 48-49-11	4.5	10.0	0.3	Moderate-steep	1.0	54	9/25	12	Medium	Temperature	Barrier dam
Montreal River	Gogebic, 48-49-10	50 5/	100.0	3.0	Slight-steep	Sluggish-3.0	52	9/22	5	Small	Temperature, spawning materials	Electrical

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2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).
3/ Applicable only to the surveyed portion of the stream.
4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.
5/ Stream tributary to another upon which it would be more practical to place a control device.

Table 22, continued

Name of stream 1/	County, township line, range, and section no. at mouth	Length of stream in miles 2/	Average width of stream in ft. 3/	Average depth of stream in ft. 3/	Range in gradient 3/	Range in velocity in ft./sec. 3/	Temperature in degrees F.	Date	Number of potential nest sites observed 3/	Productive potential	Possible limiting factors	Type of control possible 4/
Creek # 10	Gogebic, 49-46-9	1.0	6.0	0.3	Steep	1.0	52	9/17	25	Medium	Temperature, freshets	Barrier dam
Creek # 9	Gogebic, 49-46-8	1.0	4.0	0.25	Steep	1.0	52	9/17	25	Medium	Temperature, freshets	Barrier dam
Creek # 8	Gogebic, 49-46-8	1.0	4.0	0.2	Steep	1.0	54	9/17	25	Medium	Temperature, freshets	Barrier dam
Creek # 7	Gogebic, 49-46-7	1.0	2.0	0.2	Steep	1.0	52	9/17	10	Medium	Temperature, freshets, small size	Barrier dam
Creek # 6	Gogebic, 49-46-7	1.0	1.0	0.2	Steep	1.0	---	---	3	Small	Temperature, freshets, small size	Barrier dam
Creek # 5	Gogebic, 49-46-7	1.0	3.0	0.2	Steep	1.0	51	9/17	4	Small	Temperature, freshets, small size	Barrier dam
Maple Creek	Gogebic, 49-46-7	9.0	25.0	0.5	Steep	2.0	51	9/17	30	Medium	Temperature, freshets	Barrier dam
Creek # 9	Gogebic, 49-47-12	1.0-2.0	4.0	0.25	Moderate-steep	1.0	52	9/18	2	Small	Temperature, freshets	Barrier dam
Creek # 8	Gogebic, 49-47-12	1.0-2.0	6.0	0.25	Moderate-steep	1.0	52	9/18	12	Medium	Temperature, freshets	Barrier dam
Creek # 7	Gogebic, 49-47-13	1.0-2.0	3.0	0.2	Moderate-steep	1.0	53	9/18	2	Small	Temperature, freshets	Barrier dam
Creek # 6	Gogebic, 49-47-14	1.0-2.0	3.0	0.2	Moderate-steep	1.0	52	9/18	2	Small	Temperature, freshets	Barrier dam
Creek # 5	Gogebic, 49-47-14	1.0-2.0	6.0	0.25	Moderate-steep	1.0	53	9/18	2	Small	Temperature, freshets	Barrier dam
Creek # 4	Gogebic, 49-47-14	1.0-2.0	6.0	0.25	Moderate-steep	1.0	54	9/18	20	Medium	Temperature, freshets	Barrier dam
Creek # 3	Gogebic, 49-47-14	1.0-2.0	6.0	0.25	Moderate-steep	1.0	52	9/18	4	Small	Temperature, freshets	Barrier dam
Creek # 2	Gogebic, 49-47-14	1.0-2.0	6.0	0.25	Moderate-steep	1.0	51	9/18	15	Medium	Temperature, freshets	Barrier dam
Creek # 1	Gogebic, 49-47-14	1.0-2.0	3.0	0.2	Moderate-steep	1.0	52	9/18	12	Medium	Temperature, small size, freshets	Barrier dam
Nighthawk Creek	Gogebic, 49-47-15	3.0	2.0	0.2	Moderate-steep	1.0	51	9/18	10	Medium	Temperature, freshets	Barrier dam
Ghost Creek	Gogebic, 49-47-15	3.0	10.0	0.25	Moderate-steep	1.0	52	9/18	12	Medium	Temperature, freshets	Barrier dam
Creek # 25	Gogebic, 49-47-15	1.0-2.0	4.0	0.25	Moderate	1.0	56	9/20	3	Small	Temperature, freshets	Barrier dam
Creek # 24	Gogebic, 49-47-16	1.0-2.0	10.0	0.25	Moderate	1.0	57	9/20	15	Medium	Temperature, freshets	Barrier dam
Creek # 23	Gogebic, 49-47-16	1.0-2.0	6.0	0.25	Moderate	1.0	57	9/20	3	Small	Temperature, freshets	Barrier dam
Creek # 22	Gogebic, 49-47-16	1.0-2.0	8.0	0.25	Moderate	1.0	57	9/20	25	Medium	Temperature, freshets	Barrier dam
Creek # 21	Gogebic, 49-47-16	1.0-2.0	4.0	0.2	Slight	1.0	57	9/20	12	Medium	Temperature, freshets	Barrier dam
Creek # 20	Gogebic, 49-47-20	1.0-2.0	4.0	0.2	Steep	1.0	---	---	25	Medium	Temperature, freshets	Barrier dam
Creek # 19	Gogebic, 49-47-20	1.0-2.0	6.0	0.25	Steep	1.0	57	9/20	25	Medium	Temperature, freshets	Barrier dam

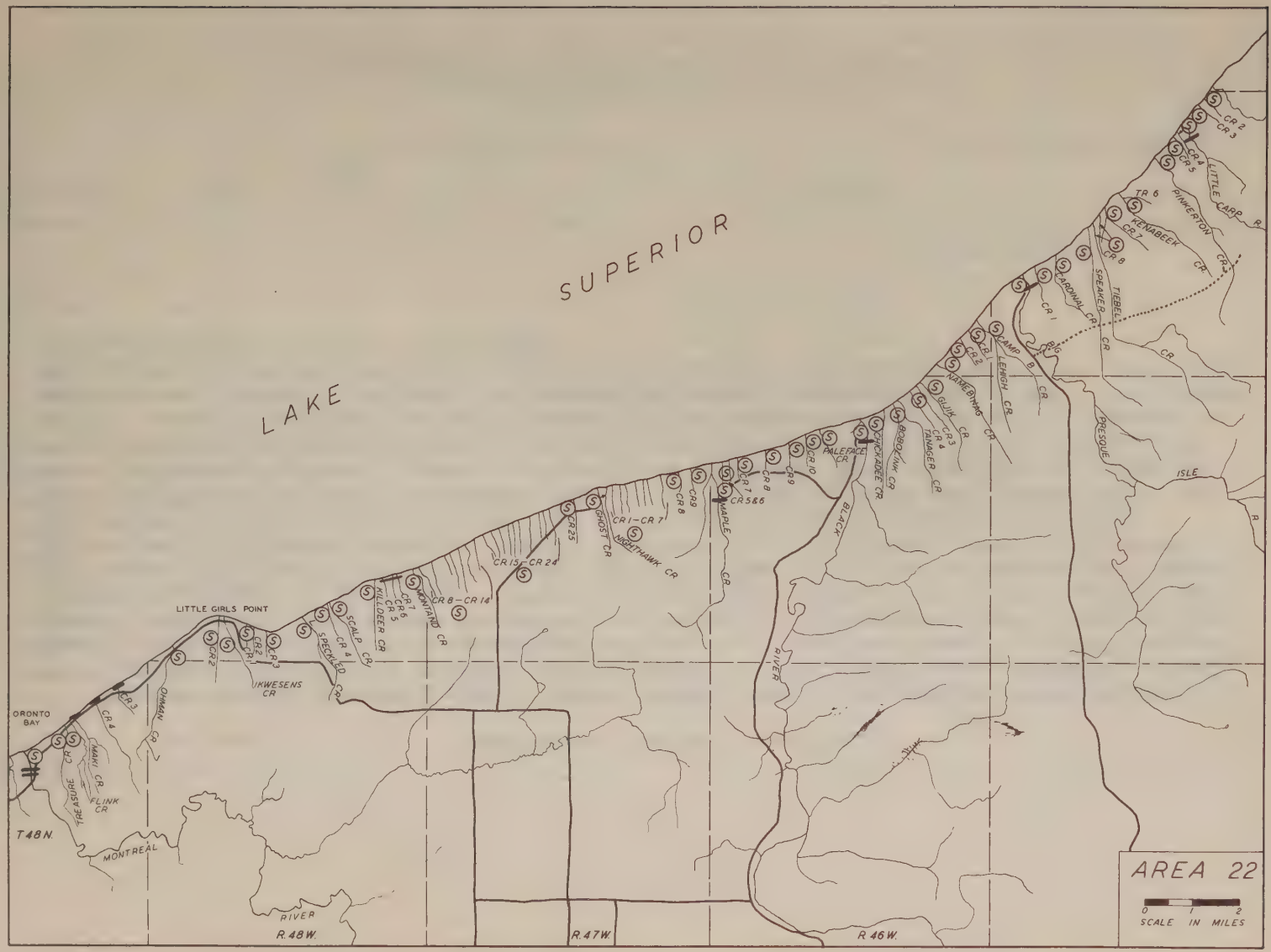


Figure 23.—Area 22.

Description of Area 22 (Fig. 23)

Embraces the entire coastal area of Gogebic County, Mich., and contains 76 watersheds in which spawning facilities are present. Seven streams, the Little Carp River, Pinkerton, Tiebel, Speaker, and Namebinag Creeks in the eastern portion of the area, and Creek No. 13 and Montana Creek in the western portion each contain facilities for 75 or more nests. Facilities for 6 to 75 nests are present in 53 streams. Sixteen streams contain sites for only 1 to 5 nests. The Big Presque Isle, Black, and Montreal Rivers are very large, and electrical devices will probably provide the only practical means of control. Barriers can be constructed close to the mouths (and below all spawning grounds) of all but 11 of the remaining streams; for the latter, electrical devices are also recommended. Many of the streams are relatively inaccessible. The stream gradients are generally steep, and velocities are high. Heavy rains tend to raise the water levels of a number of streams to the point where they overflow their banks. During such periods, turbidity is high. Low water temperatures and sudden freshets may inhibit spawning in many streams. Freshets, turbidity, and inaccessibility will offer problems in most of the streams when control devices are constructed. The surrounding country is rugged. Lake clays and a hemlock-hardwood climax type are predominant.

Table 23.--Summary of information showing utilization of streams from the Tahquamenon River west to the tip of the Keweenaw Peninsula, 1950, and from the latter point to the Michigan-Wisconsin border, 1951

Name of stream	County and T-R-S at mouth	Data obtained by survey							Data from other sources
		Number adults found	Date	Number nests found	Date	Larvae dug	Date	Identification of larvae 3/	
Tahquamenon River	Chippewa, 48-6-14	50/	6/29/50	10	6/29/50	0	...	...	Upstream migrants (adults) reported seen (resort owners) in springs of 1948 and 1949. (1949 run largest-reached peak in 2nd week of June.)
Little Two Hearted River	Luce, 50-9-24	0	...	0	...	16 1/	7/5-7/11/50	Native lampreys	...
Two Hearted River	Luce, 50-9-27	0	...	0	...	9	7/11-7/25/50	Native lampreys	4/
E. Br. Two Hearted River	Luce, 49-10-1	0	...	0	...	16	7/27-7/28/50	Native lampreys	4/
W. Br. Two Hearted River	Luce, 49-9-6	2	7/29/50	64	7/25-7/28	25 2/	7/30-7/31/50	4 ses and 21 native lampreys	4/
N. Br. Two Hearted River	Luce, 48-11-1	0	...	4	7/30/50	6	7/28/50	Native lampreys	...
Sucker River	Alger, 49-13-4	0	...	23	8/7-8/22	43	8/7-8/17/50	Native lampreys	...
Baker Creek	Alger, 49-13-4	0	...	0	...	2	8/29/50	Native lampreys	...
Tributary # 4	Alger, 48-13-1	0	...	0	...	2	8/18/50	Native lampreys	...
Creek # 3	Alger, 49-13-6	0	...	3(?)	8/9/50	0	...	...	...
Hurricane Creek	Alger, 49-15-3	0	...	0	...	8	8/22/50	Native lampreys	...
Lowney Creek	Alger, 48-16-17	0	...	1	9/10/50	5	9/10/50	Native lampreys	...
Tributary # 16	Alger, 48-17-29	0	...	0	...	2	9/14/50	Native lampreys	...
Mosquito River	Alger, 48-18-25	0	...	0	...	3	9/14/50	Native lampreys	...
Miner's River	Alger, 47-18-3	0	...	11	9/8/50	0	...	...	...
Anna River	Alger, 46-19-2	0	...	0	...	5	9/16/50	Native lampreys	...
Furnace Creek	Alger, 47-19-29	0	...	0	...	...	...	...	Dead adults observed (resort owners) on beach at mouth of stream, early summer, 1950.
Creek # 7	Alger, 47-19-18	0	...	0	...	1	9/18/50	Unidentifiable	...
Au Train River (lower)	Alger, 47-20-19	0	...	0	...	1	9/30/50	Native lamprey	Five adults and 2 nests observed, July 9, 1950. 5/

Table 23, continued

Name of stream	County and T-R-S at mouth	Data obtained by survey: Number adults found	Date	Number nests found	Date	Larvae dug	Date	Identification of larvae 3/	Data from other sources
Rock River	Alger, 47-21-15	0	...	0	...	0	...	...	Several adults observed (resort owner) below dam at mouth, spring, 1950.
Laughing Whitefish River	Alger, 48-22-26	0	...	0	...	0	...	Native lampreys	Ten nests observed, and 4 larvae dug, July 10, 1950. 5/
Chocolay River	Marquette, 47-24-6	0	...	0	...	0	...	Native lampreys	Approximately 15 adults, 113 larvae, and approximately 265 nests observed and/or recovered from 8/9 through 8/23/50. 5/
Cedar Creek	Marquette, 47-24-9	0	...	0	...	0	...	Native lamprey	One lamprey larva recovered, 9/20-28/50. 5/
E. Br. Chocolay River	Marquette, 46-24-14	0	...	0	...	0	...	...	Five nests observed 9/14 and 9/15/50. 5/
Huron River	Baraga, 52-29-18	0	...	0	...	0	...	Unidentifiable	Six larvae dug, September 1, 1950. 5/
Ravine River	Baraga, 51-31-4	0	...	0	...	0	...	2 native lampreys; 11 unidentifiable	Thirteen larvae dug, August 31, 1950. 5/
Slate River	Baraga, 51-31-8	0	...	0	...	0	...	Unidentifiable	Six probable nests observed, and 5 larvae dug, August 31, 1950. 5/
Silver River	Baraga, 51-31-18	0	...	0	...	0	...	1 native, 21 unidentifiable	Ten nests observed, and 22 larvae dug, August 31, 1950. 5/
Sturgeon River	Houghton, 54-33-33	0	...	0	...	5	8/29/50	Native lampreys	...
Traverse River	Houghton, 55-31-4	0	...	0	...	0	...	...	Five probable nests observed, July 6, 1950. 5/
Tobacco River	Keweenaw, 56-30-20	0	...	0	...	3	8/28/50	Native lampreys	...
Firesteele River	Ontonagon, 52-39-1	0	...	1	8/27/51	0	...	...	...

1/ One of the 5 taken from the stomach of an 8.5 inch brook trout.
2/ A number of larvae were also taken on August 8, 1950 from 10 sea lamprey nests with a square foot bottom sampler. These had been hatched only a short time previous to date of collection, and are assumed to be sea lampreys.
3/ Method of identification may be in need of further refinements to assure complete accuracy.
4/ Eighty larvae and 15 newly-transformed adults taken with electric shocker, October 6-10, 1950; all identified as native lampreys by Institute for Fisheries Research, Michigan Department of Conservation. The figures 80 and 15 represent the total number of specimens taken from the 3 rivers listed above.
5/ Observations by Leo Erkkila, Fishery Research Biologist in charge of Marquette, Michigan office, Fish and Wildlife Service.

LEGEND FOR MAP AREAS 1-22
(SEE FIGURES 2-23)

SPOT LOCATIONS:

ADULT SEA LAMPREYS

LARVAL SEA LAMPREYS

SEA LAMPREY NESTS

SPAWNING HABITAT

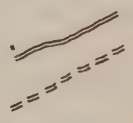
NESTS OR SPAWNING HABITAT IN EXTENSIVE AREAS

NATURAL BARRIER

MAN-MADE BARRIER

GOOD ROAD

POOR ROAD



BASE MAPS: MICH. DEPARTMENT OF CONSERVATION, COUNTY MAPS

Control procedures

Control devices may have to be installed on 194 or more streams between the Tahquamenon River and the Michigan-Wisconsin border. Tentative sites have been located on the majority of the streams, subject to change as warranted by conditions on individual streams and future developments of control devices.

The majority of streams in possible need of control are small (5 to 15 feet in width). A considerable number are in the 15- to 35- foot class. However, at least 57 are large or very large (tables 1-22).

Electrical devices have been recommended for 65 streams which are too large for mechanical weirs or barrier dams or in which good sites for such devices are lacking. Many of these sites are some distance (several miles) from the nearest power lines. Mechanical weirs are recommended for 61 streams, although it is possible that this type of device will be discarded in favor of more practical structures on individual streams (Applegate and Smith, 1951).

Barrier dams are recommended for 68 streams, many of which are difficult of access. Most of these streams are located in Ontonagan and Gogebic Counties. Banks are ravine-like and the substratum at the potential barrier sites is bedrock. Gradients are generally steep; it is believed that mechanical weirs would be difficult or impossible to hold due to the sudden rises in water levels following heavy rains. A number of these barrier dams can be constructed on bedrock outcroppings which are already partial barriers.

Beyond the usual engineering problems accompanying the installation of control devices, the main problem to be faced in the Lake Superior basin is that of relative inaccessibility. Many potential control sites are miles from the nearest roads, and can be reached only by compass course through rugged areas often covered with almost impenetrable slash and second growth.

The control program in Lake Superior logically should be initiated by constructing control devices in those watersheds in which adult sea lampreys, nests, or sea lamprey larvae have already been observed. At the close of the 1951 season these watersheds numbered 15. At the recommended control sites, the main streams of eleven of these watersheds are large, three are of moderate size, and one is small. Details concerning utilization in these particular streams are presented in table 23.

Recommendations for future work

It will be necessary, in the future, to recheck all streams with a productive potential, to determine whether or not they are being used by adult sea lampreys. It is probable that a large number of these streams will never be in need of control measures; spawning may be inhibited by low temperatures, steep gradients, high velocities, relatively small size of a number of streams, and excessive turbidities (lake clay areas of Ontonagon and Gogebic Counties). The more questionable or marginal streams should be rechecked during the regular spawning season to determine accurately their temperatures, velocities, and water levels. The true extent of spawning activity in many streams (notably in Ontonagon and Gogebic Counties) can be determined only by rechecking during the spawning season before most of the nests are destroyed by freshets.

It will be necessary also to carry out further initial surveys of all of the remaining unsurveyed streams flowing into Lake Superior, if the sea lamprey is to be successfully controlled (Wisconsin, Minnesota, Ontario streams, and those on Isle Royale and other islands which have not yet been examined). Many of the unsurveyed areas are relatively inaccessible, and will call for much more highly organized surveys than those carried out to date.

Despite the fact that various types of control structures have been recommended for streams which have a productive potential, it will be necessary to experiment further in order to develop the most practical types. Many Lake Superior streams have characteristics (steep gradients, high velocities, rapid fluctuations in water levels, and extremely heavy turbidity) which, when combined with relative inaccessibility, may present control problems not encountered in previous experimental control operations (Applegate and Smith, 1951).

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